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SCIENCE AND MATHEMATICS EDUCATION

HEARINGS

BEFORE THE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY U.S. HOUSE OF REPRESENTATIVES

ONE HUNDRED FIRST CONGRESS

FIRST SESSION

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CONTENTS

WITNESSES

Page

May 23, 1989:
- Dr. Frank Newman, President, The Education Commission of the States, Denver, Colorado 3
- Dr. Victoria Bergin, Texas Deputy Commissioner of Education for Curriculum and Program Development, Austin, Texas 48
- Dr. John J. Murphy, New York Assistant Commissioner of Education for Elementary and Secondary Planning Testing and Technology Services, Albany, New York 66

May 24, 1989:
- Admiral James D. Watkins, Secretary, Department of Energy, Washington, DC, accompanied by Toni Grayson Joseph and Richard Stephens 102
- Dr. James B. Wygaarden, Director, NIH; Dr. Charles E. Hess, Assistant Secretary of Agriculture for Science and Education, accompanied by Dr. Alvin Young, Director of the Office of Agriculture Biotechnology; Dr. John Moore, Deputy Director, NSF; Dr. Robert W. Brown, Director of Educational Affairs Division, Office of External Affairs, NASA; Frank Cipolla, Director of Management, Civilian Personnel Policy, Department of Defense 160

June 7, 1989:
- Charles Howarth, Executive Director, SCI-TECH Center, Jersey City, New Jersey; Fred Easter, Statewide Director, Lawrence Hall of Science, University of California, Berkeley, California; Dr. John Layman, Department of Physics, University of Maryland, College Park, Maryland; David Pysnik, Sidney High School, Sidney, New York, accompanied by Kerri Shea and Joseph Suriano; Sylvia Ware, Director, Education Division, American Chemical Society, Washington, DC; and Barry Stebbins, West High School, Columbus, Ohio, accompanied by Sadi Chhoa and Mittie Cheatham 334

APPENDIX

Additional statements submitted for the record:
- Statement from the National Society of Professional Engineers, June, 1989 489
- Letter from Donald E. Ledwig, President and Chief Executive Officer, Corporation for Public Broadcasting, June 1, 1989 496

SCIENCE AND MATHEMATICS EDUCATION

TUESDAY, MAY 23, 1989

U.S. House of Representatives,
Committee on Science, Space, and Technology,
Washington, D.C.

The Committee met at 9:40 a.m. in Room 2318, Rayburn House Office Building, the Honorable Robert A. Roe, Chairman, presiding.

Present: Representatives Roe, Walker, Sensenbrenner, Boehlert, Walgren, Volkmer, Packard, Slaughter, Smith [Texas), Morella, Stallings, Hayes, Tanner, and Browder.

Also present: Dr. James Wilson, Science Consultant; Harold P. Hanson, Executive Director; Dr. Grace Ostenso, Staff Director; and Robert C. Ketcham, General Counsel.

The **Chairman**. The Committee will come to order. Last month this Committee held hearings on the role of science and technology in creating the new wealth for America necessary to maintain our standard of living. New scientific and technical knowledge is the basis for new commercial products and services which we need to sustain and improve our economic health.

In addressing science and mathematics education this morning, we come to the issue which underpins our entire science and technology enterprise and therefore will largely determine the future economic strength of our nation. The effectiveness of science and mathematics education in our schools will largely determine whether or not we produce the scientists and engineers who create new knowledge and the technologically literate workforce which must transform that knowledge into useful products and services. As a nation, we must produce technically educated men and woman power at every level of management and labor. If we do not, we face a problem of crisis proportions.

We approach this discussion of science and mathematics education with the uncomfortable feeling that much is amiss. In fact, we are faced with an unrelenting torrent of bad news. It appears that American students at all levels of elementary and secondary instruction fare poorly in comparison with students from the rest of the world, including most of our major trading partners. What are our prospects for success in capturing our share of foreign trade in the 21st century if our schools are not preparing a technologically literate workforce today? Moreover, if talented students are not turned-on to science and math while in elementary and secondary school, what hope do we have for maintaining the pipeline of scientists and engineers that is necessary to sustain an advanced industrialized nation?

It is not our intention in these hearings to wring our hands over the current state of science and math education, but rather to explore ways that the Federal Government, in partnership with the States and the private sector, can bring about essential constructive change. We are particularly interested in obtaining an inventory of promising programs now underway with Federal, State or private sector support, which are successful in attracting student interest in science and technology, in improving teacher performance, and in improving the learning process through application of new technologies.

This morning we will hear about activities in the States to improve science and math curricula, including tracking the impact of changes in curricula on the performance of students. We also expect to learn about initiatives to upgrade teacher skills and to introduce applications of information technology into the classroom.

Tomorrow, representatives from seven Federal agencies will discuss current and planned precollege and undergraduate-level programs in science and math education. Our attention will be particularly focused on the nature and extent of the coordination and collaboration among the agencies, on efforts to disseminate information about successful programs to the States, and on ideas to increase the impact of Federal efforts to improve science and math education.

Finally, on June 7, we will hear from a variety of scientists and teachers, and some of their students, about some specific programs or curriculum developments which have produced encouraging results.

We look forward to reviewing science and math education programs that work and to exploring ways in which the Federal Government and States, in partnership, can revitalize science and mathematics education. We must rekindle the sense of urgency which accompanied the wave of education reform in the Sputnik era. There is no public policy issue facing us today which will have greater impact on the future well-being of the nation than the quality of education we provide for our children.

With that opening statement, the Chair would recognize the gentleman from Louisiana, Mr. Hayes, for any comments he chooses to make.

Mr. HAYES. Only to state that it bears echoing the sentiments expressed early this year by Chairman Roe, that science and technology are indeed two different words and that the pursuit of the creation of young scientists will aid the future wealth of this nation, and that the enhancement of technology is the path by which we can recover economically and again lead the world in not only the commercial impact, but in the influence that goes with the paramount position.

Over the last several decades, this country has been a source not only of economic inspiration but of political inspiration. We are seeing the consequences of that on streets as far away as China today.

With the echoing of that remark, I would hope that we keep that theme in mind as we go forward this morning.

Thank you, Mr. Chairman.

The CHAIRMAN. I thank the distinguished gentleman from Louisiana.

No further opening comments?

The Chair recognizes our first witness, the distinguished Dr. Frank Newman, President of the Education Commission of the States, from Denver, Colorado. We have your statement in full, but you can go ahead and proceed under your own direction.

STATEMENT OF DR. FRANK NEWMAN, PRESIDENT, THE EDUCATION COMMISSION OF THE STATES, DENVER, COLORADO.

Dr. NEWMAN. Thank you, Mr. Chairman, and I appreciate the chance to come.

I agree with your comment that much is amiss. I also think it's true that we've been sort of awash in statistics about how badly we're doing in math and science, and I don't see the point in repeating those. I think those are now quite clear to us. In fact, I believe a useful principle is the Noah principle, if you are familiar with it: No more prizes for predicting rain; it's time to build a few arks. I think we're at that point in math and science education.

It is clear that we are doing less well compared to the past, less well compared to the other industrialized nations and, above all, less well compared to what we need in terms of graduates of our education system in terms of what we predict in the future.

I think there are two powerful trends that have made this substantially more significant. One, of course, is the whole effect of international competition, but I want to remind you that that international competition, as the Congressman from Louisiana mentioned, is not only central, but it has had an effect of changing the nature of the workforce from a very hierarchical workforce in which very few people were expected to think, to a workforce in fact in which company after company has discovered—and you've seen that in the presidents of large corporations that have been out, arguing this case about the educational system—that they now want a workforce in which people contribute, are empowered, have learned how to think. And that is a major change that changes the nature of the kind of education we need.

The second trend is that technology is just becoming much more pervasive. There are also several very good studies now about the effect of that technology spread through society, and all of them demonstrate that one of the characteristics in a heavily technology-oriented part of the society is that people have to learn how to reason and think in abstract terms. In other words, they have to learn not just more math and science, but to think in mathematical and scientific terms in reasoning.

By abstract things, I mean being able to think about abstract concepts and apply them to pragmatic circumstances. There are several excellent studies that have looked, for example, about the effect of computerization on banks or various forms of industry. All of them find that same trend. All of these are exacerbating the need for much more effective science and math education.

So it's not just that we are not doing as well as we used to be. The demand, because of the nature of our society, has actually changed.

I think this raises a very fundamental question that I hope the Committee will keep in mind. Can we in fact improve the quality of science and math education without changing how we teach science and math? The point I want to make is that I do not believe that we can achieve any of the purposes that are in front of us if in fact what we do is simply move toward more rote learning. Rote learning has the advantage that you do learn fast, and I think it's very valuable to know something like the multiplication tables. I realize that facts, even in the world of mathematics, depend a great deal on the set of circumstances.

One of the bad mistakes we've made in the way we've drifted in our math and science education at all levels, not just at elementary and secondary, but higher education as well, is that we've drifted into implying to students that there is a clear-cut solution to every problem, one solution to every problem; that the task of the teacher is to stand in front of the student, explain the problem, explain the solution, and that's teaching.

The consequence is that we have not gotten students into the exciting process of struggling with the reasoning that goes with science and math. Now, there are a couple of reasons why we need to make an important set of changes in this. One is that when the student actually gets into an active learning role—in other words, the student is the worker of the learning process—the teacher is simply coaching—the student actually learns to make mistakes and reason—two things happen. One, the student remembers a lot more. And the second is that the student learns the process of reasoning. And since reasoning is what we're after here, unless the student actually practices the process, you can't learn the process of reasoning by someone telling you the right answer; you have to learn the process of reasoning by actually trying it.

There is a third big advantage. It's endlessly more interesting to students. One of the things we're doing now is turning off students about science and math. The National Research Council recently published a report in which they showed that 18 percent of the sophomores in high school in the United States think they would like to major in math or science or engineering. By the time they get to graduation from high school, it's down to 14 percent. By the time they're freshmen in college, it's down to 9 percent. By the time they get a bachelor's degree, it's down to 6 percent. By the time they're graduate students, it's 1 percent. By the time it's down to a Ph.D, it's a quarter of 1 percent.

The base conclusion from that is, we're turning kids off. They come into mathematics, it's boring; the implication is that only a few geniuses really can understand this. None of that is true. Every bit of evidence, and there are endless examples across the county, is that when young people are engaged actively in the process of learning to reason, they enjoy it, they learn more, they remember more, and the net effect is that we in fact jump up sharply in the amount of math and science reasoning, and it persists over time, as opposed to being a simple set of facts you learn for the final exam and then forget.

In this regard I would argue that math and science is the most crucial subject issue in the education agenda at the moment. But it is really in a way only the bellwether. Everything else that we're dealing with has to go through the same transformation, that we have to begin to think much more about how to engage the student's mind much more actively in the learning process.

Across the country at the moment, this has become the major issue in the school reform movement. The early phases of the school reform movement were all phases in which—the current school reform movement that's been going on now for six or seven years—the early phases of that were very focused on state-based mandates on such things as teacher pay or teacher testing or student testing. Increasingly now, we are talking in terms of restructuring schools. How can we get schools to be exciting learning climates? That is one of the most exciting things going on. And math and science ought to be the center point of that.

The Education Commission of the States has a major program across the country now of working with States to develop policies that encourage this kind of learning, the development of active learning on the part of the student. Very shortly, we are going to begin a major correlate program of that, a parallel program, developing new state approaches to math and science education. That comes about as a result of the growing numbers of programs and reports that you've been seeing, I'm sure, the 2061 project you are going to hear about in a while, trying to define the right goals for math and science education and create new forms of curricula. It comes about from the National Science Foundation's effort to try and create new things. But all of that needs to be coupled with what is going on in the States.

The last time we had a big math and science reform effort, after sputnik, it was heavily led and directed by the Federal Government, but without particularly effective state involvement. And as you know in this country, most education policy flows from the States. It seems to me this time the Federal Government needs to be the leader, needs to be the organizer, a sort of coherent force in it, but it seems essential to get the States to move forward in a constructive way in joining in that process and taking the lessons that are being learned and spreading them effectively throughout state government.

Some States have already moved into major new programs of math-science reform, the most prominent being Illinois, which just recently announced a major new math-science initiative. In fact, I guess you'll hear a few things out of some of the States now. Florida has a big math-science initiative on the drawing board.

So what I would argue is that this is a time in which there can be some powerful Federal-State relationships that could bring about massive changes. (A), it ought to involve the States actively. (B), it ought to involve changing the way we learn, not just what students are learning. And then, (C), I think that there are a set of more specific things that can be taken into account, and I have listed those in the testimony, but let me just list them very quickly:

Strengthening the math and science curriculum. Most States have done that, but they've not done it for all students. They assume that college entrant students need more math and science. Some States haven't recognized that math and science is now and technology is now pervading everyone's life. You can't avoid it.

Secondly, we need to think about developing new modes of testing. How we test influences what and how we teach. If we have tests that encourage rote learning, that's the kind of learning we get. If we want reasoning, we've got to have testing that encourages reasoning.

We have to think about changing textbooks. Textbooks have not only got all the difficulties we've talked about, but they tend again to focus on the coverage of material rather than modes of reasoning and learning.

We have a massive program of retraining the existing math and science teachers. We have a great many math and science teachers who are were not originally math or science majors, but transferred into those fields because of the openings there and the shortage of those teachers. That is going to require some sort of a crash effort. We need to revitalize teacher education, which again has been a weak point since so few teachers really learn how to engage students actively in the classroom.

And then finally we need to think about such things as alternative forms of certification, since there are a lot of people out there who can help in this process. If we had modes like the New Jersey mode, which is now slowly spreading across the country, of allowing people to come in from other careers, into the teaching career, go through an internship period, and bring themselves up to speed.

At any rate, I would argue that this is a peculiarly strong period of both difficulty and promise. You mentioned, Mr. Chairman, that there is a lot wrong, but it's also a period in which people are finally roused from their torpor. There are enormous numbers of efforts in the scientific community, finally, and in the education community to address those. My own sense is that this very much could be a period of real opportunity for math and science education in the United States.

I would argue we need much more than just a strong effort; we need a real crash effort, partly because we're so far behind, and partly because this is a period of opportunity. People are alert and alive to this. There is a strong educational reform movement. The States are active and anxious for federal leadership and federal partnership. I would argue it's a wonderful time for us to move ahead.

[The prepared statement of Dr. Frank Newman follows:]

Testimony of
Frank Newman, President, Education Commission of the States
Before the U.S. House of Representatives
Committee on Science, Space and Technology
May 23, 1989

Mr. Chairman:

There is no need to restate the data showing that math and science education must improve. There is widespread recognition that the United States is doing poorly in the education of its students at all levels from elementary school to the university; currently compared to the past; and particularly this country compared to the other industrialized nations. Not only do we lag behind our major international competitors, but the amount American students lag behind grows as they advance in grade. A recent study shows that at the 4th grade level, Americans are roughly in the middle of the pack - hardly exemplary but still in contention. By 9th grade we are at the bottom.

The seriousness of this is exacerbated by two powerful trends facing American society: the first is the intensifying international competition with its attendant demand for a more effectively educated workforce. A dozen major reports from leading business organizations, from state task forces and from the Education Commission of the State (ECS) have documented the fundamental shift from workers being seen as cogs in a hierarchical machine designed and operated from the top down to the challenging concept that everyone in the organization should be seen as a thinking, contributing member. As a consequence, business leaders have joined state leaders as outspoken advocates of education reform.

The second trend is the advance of the impact of technology in our lives in the workforce and in our lives as citizens and voters. We tend to think of robots, for example, as science fiction, applied in limited numbers in exotic high-tech firms. Rather, they are spreading almost without our noticing in the most prosaic settings -- think for example of the eighty thousand automatic bank tellers. As several excellent studies have shown -- and the experience of industry attests -- the result is demand for the ability to reason in abstract terms and apply the concepts to programmatic problems. Or, to put it more simply, the need is for citizens who can reason intelligently in scientific and mathematical terms.

In this need for better education, math and science serve as a bellweather for American education. These subjects represent the most urgent area of need because of the growth in importance of technology in our daily lives. But also, the nature of what is needed in math and science is also true more widely. The key to progress is not more pressure for rote learning but rather a fundamental shift in how we teach in order to insure mastery of reasoning.

Math and science serve as a bellweather in another sense -- it is in the teaching of these subjects that schools tend to be most guilty of the sin of implying to students that there is an answer and only one answer to every problem and that the job of the teacher is to tell the student the problem and then tell the student the solution. As Edward de Bono, or John Allen Paulos, or Rex Brown from ECS have been trying to tell us, math and science are more complex and more interesting than this. Knowing the multiplication table is an essential base, but that is not the end of the process. Without the student trying his or her hand at applying the concepts of numbers to real problems, the student is deprived of the excitement of learning and the chance of learning to think.

This in turn raises a question of fundamental importance. Can we change the quality of mathematics and science education without changing how we teach not just what we teach? Clearly, much of the outcome is a function of method. By method, I do not mean some "cook book" approach or fixed way of teaching, though there are a great many successful models available, I mean instead turning the classroom on its head. Instead of the teacher as worker filling the heads of recalcitrant students with pre-digested information, the student must become the worker, actively engaged in learning to think and to reason.

The teacher must become the coach. As the National Research Council pointed out, the most prevalent mode of math instruction, teacher lecturing, is the least effective. Rather teachers should act as facilitators who encourage students to solve realistic problems, explain their approaches, and work in teams to find solutions.

There are some powerful advantages in doing this. For one thing, there is no way for students to develop reasoning skills without actually trying their minds at reasoning. Also, while rote learned information is soon forgotten, when students are involved actively in the process of learning, the skills and information persist. But most important, this type of learning is far more exciting. And the evidence that math and science, as they are currently taught are not now interesting is clear. A new National Research Council report shows that 18% of high school sophomores are interested in majoring in science, engineering, and math. By freshman year in college it is 9%, by graduation 6%, by graduate school 1%, by Ph.D. degrees .25%. In simple terms, we are turning students off from a natural interest in these subjects.

As mentioned above, what is true for math and science is true for the rest of education. The reform movement in elementary and secondary education has now come to focus on the issue of how we teach. The first phase of reform focused on mandates, on steps that could be taken centrally -- teacher pay, student testing, teacher testing, curriculum requirements. Now that the complexities of the task are more apparent, the emphasis has shifted to school restructuring or redesign -- i.e. how to change the school so that students become active learners and teachers become empowered educational leaders. It will be a difficult task. Our own effort, the "Re:Learning Project: From Schoolhouse to Statehouse," is the largest, most complex project the Commission has ever undertaken. This project involves five test states. Similar projects are underway in cities such as Miami, Los Angeles, Pittsburgh, and Rochester.

What can be done that will encourage new modes of teaching of math and science? What steps encourage the redesign of schools? Here are a few:

- **Strengthen the math and science requirements for all students.** Most states have already made more explicit their curricular requirements usually increasing the number of courses required. In many cases, however, schools have simply taken the same material and spread it over another year. These requirements also need to be in effect for all students, not just the college-bound. Of course this will reveal even further the need to restructure how we teach since it is the students who get the least in the way of math and science instruction that we bore the most.

-- **Develop new modes of testing.** Since, over time, schools tend to teach to the tests, if we wish students to be able to reason we need modes of testing that measure the ability to reason. In recent years, there has been much progress in developing better forms of assessment, but most testing now in place measures only information retrieval.

-- **Change textbooks.** Most textbooks treat math and science as collections of facts to be learned. Textbooks are adopted centrally in 23 states, influencing what all states can purchase. The five year adoption cycle means that the material is always out of date. The Japanese use paperbacks which not only allows the student to keep the book, but focuses the publishers energy more on the context and less on the binding and paper quality.

-- **Retrain existing math and science teachers.** This is an enormous task that should not be underestimated. Many current teachers shifted into math and science because of the openings. A sizeable share of all math and science teachers are not comfortable enough with their own understanding of the subject to help students learn to reason. Some sort of crash program is needed, perhaps utilizing people now in industry or retired from industry to supplement the talent available to the schools.

- **Revitalize teacher education.** The urgency of this goes far beyond the need for teachers better trained in math and science. The success of the school redesign effort depends on a steady flow of new teachers who know their subject area thoroughly, know how to engage children actively in class and not just lecture, and are self-confident enough to become change agents when they arrive in the schools.

- **Provide alternative forms of certification.** We need a flow of able, experienced people into the schools from many directions.

What is it that will stand in the way of progress? It is certainly not a lack of attention on the part of the responsible organizations. The American Association for the Advancement of Science, the National Research Council, the National Council of Teachers of Mathematics, the National Science Education Board, the National Science Foundation, and ECS have all recently announced major programs or new reports. States are beginning to act -- Illinois just announced a new, comprehensive program, Florida has one in the works.

What is more of an obstacle is the lack of belief that every student can master math and science. For a long, long time, even well educated people have indulged themselves the luxury of "mathematics is simply not for me," or "I was never good at math and science." Since we do not believe we can learn, we can hardly fault our sons and daughters or the schools. The now familiar story of Jamie Escalante, the teacher at Garfield High School in Los Angeles, made famous by the movie, "Stand and Deliver," reminds us that the least motivated and successful students can learn advanced math, and enjoy it, if the teacher engages their minds through an active process. Literally thousands of such examples prove that we all can learn under the right circumstances.

The other great concern is that once again, as was done after Sputnik, there will be an attempt to bring about change through a top down approach in a national program. To be successful, any approach that will truly change how we teach as well as what we teach must involve states and school districts. No one approach will fit all, but common principles can be generated. Incentives to change must be established. New policies at the state and local level must be created that encourage active rather than passive learning. A broad public campaign must be formulated, for unless the public is demanding change, believes we can change, and believes students can learn math and science, nothing permanent will happen.

We need a crash effort because we are so far behind. But we need a thoughtful crash effort because the issues are so complex. Most important, we will not get more unless we expect more.

The CHAIRMAN. The Chair wants to thank you, Dr. Newman, for your splendid presentation. Without objection, your statement will appear in full in the record.

You make some very definite points. What we are attempting to do, this is the last leg of this series of hearings on creating the new wealth for America, which I am sure you are aware of, and we look at science, space, technology and education particularly to be the underpinning foundational issue of the whole situation.

Then I think it's on page 3 of your testimony. You say, quote: "Supply of future scientists and engineers is also endangered by decreases in the number of students that are interested," as you testified to, "in science and mathematics at the same time when the size of college-age population is declining by 25 percent."

We're trying to get across to industry in this country that it's not just this Committee in science, space, and technology education that's the issue. We're trying to say to them that their future managers and the people they're going to need to run their corporations have to be much more technically trained than they are today and they have to be able to articulate in really a global economy. It's no longer what we're doing in the United States; it's what happens in Europe in 1992, what happens in the Far East particularly.

Having said that, you made a couple of very important observations. One has to do with the reeducation of the teachers. I think that is a very, very important issue.

What do you see from your State's point? How would we do that? If the Federal Government is to take the lead, knowing budget constraints and so forth and so on, is it a question of redirecting, for example, in the educational funding process to the States and setting new directives there? Suppose you were a king, what would you do to reeducate the teachers—and God, I wouldn't wish that on anybody—being king, not reeducating—

Voice: I would abdicate.

The CHAIRMAN. Yes, I would abdicate. Me too.

[Laughter.]

Dr. NEWMAN. Could I just go back to something you said?

The CHAIRMAN. Yes. Sure.

Dr. NEWMAN. The technology spreading. Let me give you just one example.

The CHAIRMAN. If the gentleman would yield. I am not talking about technology spreading. We are trying to educate the Congress—this committee is—

Dr. NEWMAN. Yes.

The CHAIRMAN.—that science, space, technology and education is where new elements of wealth are going to come into this country.

Dr. NEWMAN. Absolutely.

The CHAIRMAN. That is where the whole productivity is involved, never mind this competition nonsense. We know that is there. We can't look at what happened yesterday. We are coming back and saying that as we allocate resources today in the 1990 budget, as we choose priorities, the question is, what does Congress do in science, space, technology and particularly education, not more money into education, but to refine the educational process to meet the needs of the 21st century, which is 11 years away. That is what this issue of new wealth is about. And we are coming back and saying that is Congress doesn't do something like that, and they go and cut out this project and that program and this program and this program, because we are trying to meet housing needs, and the homeless and so forth, in a very few years we will run out of options, because the wealth will not be there any more.

So that that is how important this chairman believes this issue is.

So if you would proceed from there. I just want to set that stage.

Dr. NEWMAN. No, I think that's absolutely right. I was going to say that one of the things that has hampered science and math education is that historically many of us excused ourselves from learning science and math on the grounds that, well, it was important, but not particularly for me. I am not in a field. I am not in a high tech industry, and so on. And what you are really saying as I hear you, which I totally agree with, is that those days are gone. It is now important to all of us.

I have been playing a parlor trick with audiences of saying, where are the most robots in the world? And of course, everybody answers Japan, and I say what industry, and they all say automobile industry. That's wrong. The most robots are in the United States in banking. A machine you go up to, and no one every things of banks as—

The CHAIRMAN. You'd better clarify that. Robots in banking. That would make a good title for a good book. But go ahead.

[Laughter.]

Dr. NEWMAN. Well, no one thinks of banks as centers of robotics, but of course, they have become that. And every field is suffering, and just the ordinary task of citizenship requires you to be able to think in these terms. So I totally agree with you.

Back to your point. What can the States do and how do we think about the question of both retraining teachers and training new teachers? I want to remind you that the problem is severe on both sides of that.

On the retraining of teachers, there is a growing debate about this within the United States, about how to do this.

The CHAIRMAN. Is it possible to retrain teachers?

Dr. NEWMAN. Yes. And I would say that one of the more interesting examples is the City of Pittsburgh, which has had excellent leadership in the schools. The superintendent, Richard Wallace, is a man who I think has tackled the question of retraining in a very interesting way. What he has done is create a retraining institute called the Schenley Institute, and industry has helped him put it together. And in groups of 200, they have taken the teachers—and they provide the time off for the teacher—

and the teacher goes to an intensive retraining effort.

The beauty of the system is, first it is run by the school system, so that it is really focused on what the teachers actually need to know, and secondly, the teachers go in groups of 200—not from the same school—so that they are with their colleagues, struggling with the retraining process, and not only what it is they need to know but new modes of teaching, how do they get into much different modes of classroom behavior. So that you are not alone. It is not that you are a dummy and all the rest of the world really understand, you are with colleagues. You are struggling as peers together in this process.

They have made a lot of progress. Of course, some modest measures of funding are involved, but the real thing that needs is initiative, and I think there are several ways the Federal Government can help achieve those things. I think that the Federal Government often does superb things with small amounts of money on sort of a competitive grant basis that get people thinking properly. You have an agency, the Fund for the Improvement of Postsecondary Education, which has been extraordinarily effective at things like—it is focused on higher education, but on things like teacher training or on teacher education in the universities. You can use that fund very effectively where small amounts of money get large numbers of organizations coming in with proposals. And once they start making proposals, whether they get a grant or not, you've already got them. They are hooked on the process of how do we bring change? How do we bring change?

You can provide small amounts of matching money to the States, asking them to come forward with competitive proposals on how they would do the teacher retraining within their States, and you will find some very interesting answers. Some States have gone a considerable distance on their own. South Carolina, for example. So I think with very small amounts of funding, the Federal Government can play a major role in pushing people to think in new and more imaginative terms about a problem that they've got on a massive scale.

The CHAIRMAN. Tell me one more question. What about textbooks? I have been talking to a lot of people throughout the country, and they tell me that our textbooks for the 21st century are abominable now as far as teaching aids are concerned. What do you find on that?

Dr. NEWMAN. "Abominable" would be—

The CHAIRMAN. Too strong.

Dr. NEWMAN. Well, how about stink?

[Laughter.]

The CHAIRMAN. Yes. Okay.

Dr. NEWMAN. For a couple of reasons. One of the things I mention in the testimony is that the Japanese have tended to go to paperback textbooks, which has a couple of advantages. One that they can—

The CHAIRMAN.—put them in their pocket.

Dr. NEWMAN. Put them in their pocket and keep. The kids end up keeping them.

The second is that their time cycle is much shorter. We have evolved, unfortunately, and it is something the States are beginning to look at, but it is going to require some State action. A number of the States now have major textbook approval. It has developed over the years and 23 of the States have centralized textbook approval. One of the troubles with that centralized textbook—

The CHAIRMAN. What do you mean "centralized"?

Dr. NEWMAN. The State.

The CHAIRMAN. Central in the State, centralized in the State?

Dr. NEWMAN. Yes.

The CHAIRMAN. Okay.

Dr. NEWMAN. It is centralized at the State level, and the State makes a decision: these seven textbooks would be acceptable for teaching math in these grades and so on or these two textbooks, or so on. The difficulty of that State—it started as a perfectly rational thing to try and improve the quality, but what it tends to become is a political process with a long time dimension to it, and then there gets to be an argument. Everybody wants something included, so somebody is very much in favor of the binomial theorem, so they want to make sure that gets in there, and somebody else wants the geography of Alaska, so that gets in there. What you end up with is a hodgepodge rather than a coherent textbook that focuses on reasoning. I think that simply is—it is now a subject at the State level, it is going to be a hard battle, but I think we have got to get at that, and we have to encourage the textbook manufacturers to have a little courage and come forward with better textbooks.

The CHAIRMAN. Questions. Mr. Hayes from Louisiana is recognized.

Mr. HAYES. Would you elaborate just for a moment on the one sentence on page 7 of your written testimony on alternative forms of certification—"We need a flow of able, experienced people into the schools from many directions." Elaborate a moment; tell me what that means.

Dr. NEWMAN. Well in essentially every State, to become a school teacher requires that you be certified by the State. Almost always that, in turn, requires that you graduate from a teacher education program and that you have certain amounts of credits and certain amounts of teacher education courses. So that let's suppose that you are living in Louisiana and you move, and you have been, say, in some perfectly rational occupation, say you have been a Congressman. That is a conflict right there, isn't it, a perfectly rational—and you move to New Jersey and you want to become a school teacher.

Mr. HAYES. This surely is a conflict.

Dr. NEWMAN. Yes.

[Laughter.]

Dr. NEWMAN. Well, you wouldn't do that, I know, but this is a hypothetical case. But at any rate, when you arrive in New Jersey, you say, I am going to change my life, I am going to become a school teacher, and you go down and you say, I have spent a lot of my life, I have cared a lot about mathematics; I am good at mathematics; I would like to teach. I say, I'm sorry; you must go back to school; start; go through a teacher education; get a degree; get certified; and so on Well, obviously, that is impractical. New Jersey as pioneered a mode by which a person with considerable experience can come forward, go through a short training program, become an apprentice teacher and take some additional work while you are in the apprentice teacher program and become a teacher.

Mr. HAYES. And be certified within that single field rather than certified as—

Dr. NEWMAN. Well, be certified as are other teachers. The beauty of it, as it turned out, when New Jersey began the program, the question everybody had, would there be talented people who would want to do that, and it has turned out that there are very large numbers of people with all kinds of education credentials, Ph.Ds., law degrees, all kinds of things. But we have been holding them out by the artificial nature of the certification process.

Mr. HAYES. Would you also make a suggestion of separate pay scales in separate fields to attract people from other areas who could become certified with that target. In other words, perhaps there is a role of government at all levels, especially the school board level in the local county—I am having trouble with the word "county." I think in terms of "parishes."—but at the local county wishing to target an interest, do you view that as a workable approach, or does that lead to so many internal conflicts among different bodies of teachers as to disallow the facilitation of attracting from a particular need?

Dr. NEWMAN. Well, I think it actually does tend to lead—at the moment at the elementary and secondary level. I think it actually leads us to more problems, primarily because the ethic, the tradition is so much against it at elementary and secondary. Of course, that is what we do at higher education, and it works. So far, actually in alternative certification in math and science teaching, when the doors are open, it hasn't turned out to be necessary to have higher pay scales—

Mr. HAYES. I would like to ask you a question on the pay scale issue. I notice also in your written testimony, I would be interested in your view of two pay scale issues rather than a single one. I think we think of that in terms of pay scale for teaching as opposed to situations. I was inducted last night into having to help Jonathan Hayes with his math homework. It had been quite sometime since I had done it, and yet it was instantly no problem, because the background that I got in a public high school I wish it was as good today as it was then. But the teacher that I had—and recently there was an interesting article about her in the press as one of the half dozen in Louisiana under an issue called "Mothers for Us all for the Committee" in a mother's day issue. But she left teaching and went into the school board and administration because it was the only way to get increased pay.

In other words, the only conduit for an increased salary was to leave what she did best, and I could still after 30 years instantly do what I was taught to do, with a different text, with a different teacher, in another State, not mechanically, because I no longer remember the formulas, but as you are talking about, the formal thinking never changes. No, I remember the easy ones. I don't remember the areas of trapezoids. That takes a second, but the minute you flip the page, that is not the relevant point, the relevant point is, you know how to find it so rapidly and how to think it through without the formula. That is a gift, and that is really the gift that you are seeking.

But comment for me on that salary, not only a salary of enticing, at levels that entice people in, but in keeping them there, and in not making them leave in order to subsequently increase the salary by taking them out of the classroom.

Dr. NEWMAN. Well, I strongly agree with that as an issue, and as a matter of fact, over the last couple of years, last five or six years, States have really been grappling with that. They have basically failed to institute merit pay plans. Resistance among teachers unions has been so strong to that, that there is no State now that has stayed with any of the attempts to create a merit pay plan. What has happened is that several quite a few States now have some mode of addressing that. Career ladders is one example, where excellent teachers like that that can move up on a career ladder. Master teacher plans are another place like that. Several are now experimenting with master teacher plans where that kind of a teacher, a really able teacher becomes not only a master teacher, in the sense of getting more pay, but serves as the mentor for apprentice teachers coming in and has connection the teacher—

Mr. HAYES. I don't want to take any more of the time; there are others here, but let me ask one more question.

Name for me a few States that you would look toward on the master plan ladder plans you just mentioned as models to watch in the future and see how those programs are working.

Dr. NEWMAN. Well, probably the key one is Tennessee, which was sort of the pioneer of it.

Can I just add one point on the thing.

Mr. HAYES. Please.

Dr. NEWMAN. There is another point about keeping people like that in teaching. The thing that has turned out to be more powerful than pay is the sense that most teachers have that they are just a cipher, a cog. We ran a program where we had governors sit down and talk directly with teachers around the country, and what we discovered was the median time that the teacher spends talking to the principal about how the education process or the school ought to run is zero. In other words, most teachers never talk with the principal about how are we going to improve math and science education.

The teacher goes in; sits in the classroom; the principal worries about the adminstration of the school. And what we need to do, and that is why the process of restructuring schools has now become so important. Teachers need to be part of an exciting process where they are considered human beings and have something to contribute. We are out in the middle of trying to restructure the automobile plant so the workers can contribute. We ought to start with trying to restructure the schools so that the teacher can contribute.

Mr. HAYES. Thank you very much.

The CHAIRMAN. The Chair recognizes the distinguished gentleman from Pennsylvania, the ranking member, Mr. Walker.

Mr. WALKER. Thank you, Mr. Chairman. First, Mr. Chairman, I would ask unanimous consent that the statement I had in the hearing would be included.

The CHAIRMAN. Without objection, so ordered.

Mr. WALKER. Thank you.

[The prepared opening statement of Mr. Walker follows:]

HONORABLE ROBERT S. WALKER
OPENING STATEMENT
FULL COMMITTEE HEARING ON SCIENCE EDUCATION
MAY 23, 1989

MR. CHAIRMAN:

AT JUST ABOUT EVERY HEARING WE'VE HELD THIS YEAR, NO MATTER WHAT THE TOPIC, OUR WITNESSES HAVE OFFERED A PLEA FOR US TO HELP IMPROVE THE QUALITY OF EDUCATION.

WE'VE BEEN TAKING IMPORTANT STEPS IN THAT DIRECTION, SUCH AS THE PACKAGE OF SCHOLARSHIPS REPORTED OUT BY THE SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY.

THIS SET OF HEARINGS IS ANOTHER VALUABLE STEP BECAUSE WE WILL HEAR FROM PLAYERS AT THE FEDERAL, STATE AND LOCAL LEVELS TO GAIN A COMPREHENSIVE PICTURE OF WHAT IS BEING DONE AND CAN BE DONE TO IMPROVE SCIENCE AND MATH EDUCATION.

THE MOST SUCCESSFUL INNOVATIONS HAVE - AND SHOULD - COME FROM THE STATE AND LOCAL LEVEL, AND I HOPE OUR WITNESSES TODAY WILL SUGGEST SOME PROGRAMS THEY FEEL CAN BE REPLICATED IN OTHER STATES.

INDEED, I BELIEVE ONE OF THE MOST USEFUL STEPS THE FEDERAL GOVERNMENT COULD TAKE IS TO PULL TOGETHER INFORMATION ON WHAT IS BEING TRIED AROUND THE COUNTRY.

I WILL BE INTRODUCING A BILL THAT WOULD HAVE THE NATIONAL SCIENCE FOUNDATION PRODUCE A LIST OF PROGRAMS IN WHICH BUSINESSES AND SCHOOL DISTRICTS ARE WORKING TOGETHER TO HELP UNDERPRIVILEGED KIDS ACHIEVE IN SCIENCE AND MATHEMATICS. THE REPORT WOULD ALSO INCLUDE AN ANALYSIS OF WHAT ELEMENTS ARE NECESSARY FOR A SUCCESSFUL PROGRAM AND OF WHAT THE FEDERAL GOVERNMENT COULD DO TO ENCOURAGE THE PROLIFERATION OF SUCH EFFORTS.

THIS MORNING'S TESTIMONY SHOULD GIVE NSF A GOOD HEAD START ON THAT REPORT.

THANK YOU.

Mr. **Walker**. The idea of school restructuring, I think, is very important in addressing the future.

Would you comment on the idea that probably as we approach the next century that we are literally going to have to look at lifetime learning, that we can no longer think of 12 years of school or 18 years of schooling, in the traditional sense that school is just one period of your life, then you go out and you take a job but, rather, that people are going to have to be convinced that learning is a lifetime experience, because you are going to go into so many different jobs during a period of your life that you are literally going to have to restructure the schools to adapt to lifetime learning. I just would appreciate your comments.

Dr. **Newman**. Congressman, I think we are a quarter of the way already there. I think you are absolutely right. The average American, if you look at 20 years out of college, just looking at college— There is a number of colleges that have studied this—takes 2-1/2 entirely different types of jobs. I don't mean that they have changed jobs. I mean that they have gone into different things. For example, they were a lawyer and they become a Congressman— well, you know what I mean, at any rate.

The **Chairman**. That wasn't a very good analogy, Dr. Newman. We would like to see more engineers become Congressman.

[Laughter.]

Dr. **Newman**. Right. They are an engineer and they become a Congressman is what I meant to say.

[Laughter.]

And so one of the interesting things about the United States is, we sometimes fail to realize that the higher education system in this country has already moved to the point where there are now about 12.5 million students in higher education. About 6 million of those are students older than the traditional college age. So we already have a very high degree of this happening. The trouble is, it is going to have to increase, and it is going to have to be much more widespread, particularly for people—one of the reasons why we have to restructure schools is it has to be more widespread for people who haven't enjoyed schooling as they now know it. The problem is, it is awfully hard to tell somebody who finally struggled through school, got out, found it the most boring experience they ever went through, to tell them, isn't this good news? You are going to have the opportunity to go back to school for the rest of your life. And they're saying big deal.

So we have got to make schooling an interesting and exciting process, not what it is now for most people: boring.

Mr. **Walker**. But the fact is—I am a former teacher.

Dr. **Newman**. Oh-oh.

Mr. **Walker**. And I find a lot of students—

The **Chairman**. He's also a Congressman.

[Laughter.]

Mr. **Walker**. That's right. I've had at least two experiences.

I find that a number of the students who I talk to—I have been out of the schools now 20 years, but a number of my former students that I run into will say I wish I had known in school what I was going to be doing in later life, because I would have put a lot more emphasis on certain things. My guess is that as people mature, they find a need for some of the things that they found boring in school, that there are people who find themselves in a job where math and science all of a sudden have become important to them. They see a need to learn some of these things that didn't seem at all important to them in school.

If we had a school restructured in a way to accommodate that, my guess is that you could find an awful lot of people learning things that they now are either ignorant about or simply saw no need to spend much time with when they were in school, so are not totally ignorant but simply don't have up-to-date knowledge about these things.

Dr. NEWMAN. Although that is going to happen and is happening, mostly within the higher ed system, primarily in things like community colleges and in universities that have continuing ed programs, primarily because the people that are already out of high schools don't want to go back with school children. They want to go ahead with their colleagues who are adults.

Mr. WALKER. I understand, but I guess my point is, would you agree that we have not seen very much in the way of public school accommodation of that, of the public school system, yet you have public school facilities literally lying fallow for parts of years, in evenings, you know, all kinds of facilities are available to have this kind of system instituted now, and yet very little movement toward doing it because there is a resistance on the part of people within the profession of moving in that direction.

Dr. NEWMAN. I think that is true, and I also think that the point you are making is absolutely right, and we are going to see that continue to accelerate through the future. There is absolutely no reason to think that this isn't going to accelerate.

Mr. WALKER. And isn't there some need in this business of teacher retraining to also look at the way in which the educational system is taught within the teacher training process? I agree with you, that on the outside, that bringing in people from other professions to come back in and train there, but it seems to me that the teacher training efforts in this country are almost ludicrous in what they are teaching people that they need to know about being teachers. I mean, we basically take them in there and we train them in educational history and a number of things like this that give them absolutely no practical knowledge about what it is they have to do in the classroom. As a result, we are putting people in the classroom who think that if you do teach the way they just saw college professors teaching that that is somehow going to reach elementary and secondary kids, and it just doesn't. I mean, they are competing with television. You have teachers who are competing as an information source with TV, and they are losing, and they will continue to lose until we change the structure of teacher training, so that they are adequate communicators to kids that have fantastic communication sources available.

Dr. NEWMAN. Well, there has been over the last four or five considerable criticism—carefully documented criticism of teacher education, and I share those criticisms. I think that we have a long way to go. The American Association for Higher Education, coupled with ourselves and with John Goodlad, the scholar at the University of Washington, have under way a major effort at trying to now take all these reports—in all of these issues, everything you are talking about, it is not that we don't know what to do, we have a lot of information on what to do, the problem is to start doing it and getting the forces that will help bring it about.

AAAG has formed what is called the Presidents' Forum for teaching as a profession, which is a group of university presidents who have agreed to try to push these reforms through of the kind you are talking about. But changing teacher ed, you know what Clark Kerr said about changing universities—it's like moving a cemetery. It is very hard to do, and there is no internal support. And that is why we need the force of Congress and the States to make change.

Mr. WALKER. Thank you, Mr. Chairman.

The CHAIRMAN. If the gentleman would yield, you know, I just want to press you on a point, if I may, Doctor, the point that Mr. Walker was making. If we know what to do, that is the purpose of this hearing, why don't we do it?

Dr. NEWMAN. Well, all organizations—and education is no different than any other. All organizations change because there is outside stimulus. And the thing that the Federal Government is good at and has done superbly is literally create the outside stimulus that has moved the education system.

When we were talking about, a moment ago, about teacher education and the universities, think of the massive changes that have gone on in the universities in the postwar period. Many of those have been triggered by things that you in the Congress have done, almost always over the objections—

The CHAIRMAN.—of the establishment.

Dr. NEWMAN.—of the establishment. The G.I. Bill was a wonderful thing. If you go back to the G.I. Bill and read the legislative history, every university president that testified—

The CHAIRMAN.—opposed it.

Dr. NEWMAN.—opposed it.

The CHAIRMAN. Yes.

Dr. NEWMAN. And now if you use ask the university presidents, they think they invented it.

The CHAIRMAN. Yes.

[Laughter.]

Dr. NEWMAN. And there is nothing wrong with that. There's nothing wrong—

The CHAIRMAN. You're making a good point. I want to give others a chance. Forgive me for interrupting. When I first became chairman of this committee, one of the things we did was to meet with the heads of the five or six different major organizations in the country for education, and I had the temerity—first, I listened, which is difficult for me to do. And then I had the temerity to ask a question. We were talking about science and technology in the first grade, and I couldn't understand where these youngsters can take these Atari toys—in fact, I went to a wedding Sunday, and the gal who was the—what do you call it—the flower girl, she was one year old! My God, I couldn't believe. I thought I was getting old. She was one year old, and that kid walked right up that aisle at one year old, and she carried that little basket. She knew exactly what to do. Of course, when she got a little bit bored, she sat in the middle of the step while the priest was trying to go through thing and she wasn't going to leave, and it didn't matter, so she sat there. But she was one year old.

And you know, the kids take these Atari toys—and another digression if my members will forgive me. I called up my nephew. I wanted to talk to him; he wasn't in, and his son answers the phone. His son is five years old; his name is Sean. And I said, "Sean." And he says, "Hello, Uncle Bob." He's real quiet. I was wondering what was going on. I said, "What are you doing?" "I'm looking at a movie." I said, "Well, what movie are you looking at?" He was looking at "Star Wars." "I'm looking at Star Wars." So I didn't carry it any further than that.

The point I am trying to make is, those people responded to me, and having served also in State government at cabinet level, those people responded to me that represented the institutions of this country, and they said to me—I said to them, "Well, why is it we don't do this in the first grade or second grade?" And enthusiasm. "Well, Congressman, you know, I know you're new at this"—of course, I've been in the committee 21 years. "I know you're new at this, but it is the mores of the tribe." And I said, "Tell me, what do you mean "the mores of the tribe?" "But it will take two or three generations before we can get to that point." And I said to them, "If were governor of my State"—and damn near was at one occasion—"the first thing I would do would be to call in my commissioner of education and tell him within 30 days I wanted a curriculum to start to teach science and technology in the first grade, and if you can't do it, I am going to get some other commissioner that can do it!

Now I don't mean to minimize this issue, because I don't mean to be flippant either, but it seems to me, if I hear what you are saying, you are saying that at this stage, regardless of the issue, that the Congress must make some dynamic move to say to the educational institution, this is the way we are going to start to go.

Dr. NEWMAN. Thoughtful and dynamic.

The CHAIRMAN. Well, of course. We never do anything that is lesser than thoughtful around here.

[Laughter.]

Dr. NEWMAN. Well, I do agree exactly with that, and that the Congress has the power to stimulate, move—the States are going to make education policy, but you can make them move, and they are very much in the mood to move. The governors are saying those kinds of things, and the governors have been the driving force of education—governors and legislators have been the driving force of educational reform for the last five or six years, not the system itself. And I don't mean that there aren't within the system excellent people with excellent programs.

We were just talking a moment ago about some of the programs around the country. We have some superb programs here in this country. The problem is not whether we can find a program in the State of Texas or the State of Louisiana or North Carolina or North Dakota. We can find them. We can find schools that are already restructured that are functioning beautifully. We can find teachers who would provide the kind of education Mr. Hayes was talking about. The problem is, can we scale that up, so that the country as a whole looks very different, and what that takes is the capacity to move organizations that are stuck in their ways. They are not any different than the others. I mean, look at the legal profession? I don't see the lawyers running around trying to improve what we know is an overburdened and difficult legal profession or the doctors running around worrying about containing costs..

So the educators are no different in that sense. In fact, they may be better, but they do need that stimulus, and that, I think, is the role of the Congress.

The CHAIRMAN. The Chair recognizes the distinguished gentleman from Pennsylvania, Mr. Walgren.

Mr. WALGREN. Thank you, Mr. Chairman. Mr. Chairman, I would like to ask unanimous consent that my opening statement be included in the record.

The CHAIRMAN. Yes. No objection. So ordered. And I understand there's other Members who have opening remarks that they want to enter into the record, if no objection, can do so at this point.

[The prepared opening statement of Mr. Walgren follows:]

Opening Statement
U.S. Rep. Doug Walgren (D-PA)

Committee on Science, Space, and Technology Hearing on Science and Mathematics Education

May 23, 1989

MR. CHAIRMAN, THIS MORNING WE WILL LAUNCH A SERIES OF HEARINGS ON THE MOST SERIOUS LONG-TERM PROBLEM FACING OUR NATION - SCIENCE AND MATHEMATICS EDUCATION. AS WE ARE ON THE VERGE OF ENTERING A NEW CENTURY, THE WORLD IS CHANGING AS A RESULT OF NEW TECHNOLOGY APPLIED TO EVERY ASPECT OF LIFE. AMERICA'S ABILITY TO ADAPT TO THESE CHANGES AS WELL AS IT'S LEADERSHIP IN THE ECONOMIC, SOCIAL AND MILITARY ARENAS WILL DEPEND ON THE QUALITY OF SCIENCE AND MATHEMATICS EDUCATION; ESPECIALLY IN THE PRECOLLEGE YEARS.

THE CRISIS IN SCIENCE AND MATH EDUCATION IS SERIOUS AND GETTING WORSE. ACCORDING TO AN INTERNATIONAL STUDY, AMERICAN GRADE SCHOOL AND HIGH SCHOOL STUDENTS LAG FAR BEHIND THEIR FOREIGN COUNTERPARTS IN SCIENCE AND MATH PROFICIENCY. THESE AND OTHER DISMAL FINDINGS ARE DISTURBING AT A TIME WHEN WE ARE NOT DOING WELL IN INTERNATIONAL ECONOMIC COMPETITION THAT REQUIRES A TECHNOLOGICALLY LITERATE WORKFORCE. MOREOVER, OUR SOCIETY WILL BE CALLED UPON TO MAKE SOCIAL AND ECONOMIC DECISIONS THAT WILL INVOLVE SCIENTIFIC ISSUES. IF OUR DEMOCRACY IS TO WORK AS IT

SHOULD, EVERY CITIZEN MUST BE CAPABLE OF GRASPING PROBLEMS INVOLVING SCIENTIFIC ELEMENTS.

THE TASK WE FACE IS VERY CLEAR: WE MUST IMPROVE THE QUALITY OF SCIENCE AND MATH EDUCATION FOR ALL STUDENTS IN GRADE AND HIGH SCHOOL. UNFORTUNATELY, THE SOLUTION TO THIS MANDATE IS NOT SO SIMPLE. STUDENTS, TEACHERS, ADMINISTRATORS, SCHOOL DISTRICTS AND STATES ALL HAVE DIFFERENT CHARACTERISTICS AND NEEDS. IN ADDITION, EDUCATORS, SCIENTISTS, MATHEMATICIANS, TEXTBOOK PUBLISHERS AND MANY OTHER EXPERTS BRING DIFFERENT TALENTS AND PERSPECTIVES TO THIS PROBLEM. SOMEHOW THERE MUST BE A COORDINATED DRIVE TOWARD A SOLUTION.

TODAY, AND IN THE OTHER HEARINGS SCHEDULED ON THIS SUBJECT, WE WILL HEAR FROM REPRESENTATIVES OF THE MANY ELEMENTS IN THIS COMPLEX EQUATION. I HOPE WE CAN LEARN MORE ABOUT THE NEW AND INNOVATIVE METHODS BEING IMPLEMENTED ON THE STATE AND LOCAL LEVELS, AS WELL AS WHAT IS BEING DONE BY THE SEVERAL FEDERAL AGENCIES CURRENTLY INVOLVED IN EDUCATION. FROM THESE HEARINGS I HOPE WE CAN DEVELOP A KEEN SENSE OF DIRECTION AND WHAT SHAPE THE FEDERAL ROLE WILL TAKE IN IMPROVING SCIENCE AND MATH EDUCATION.

MR. CHAIRMAN, I WANT TO THANK YOU FOR CALLING THESE

HEARINGS AND LENDING YOUR STRONG LEADERSHIP TO THIS PROBLEM. AS CHAIRMAN OF THE SUBCOMMITTEE THE SCIENCE, RESEARCH AND TECHNOLOGY, I LOOK FORWARD TO WORKING WITH YOU AND ALL THE OTHER MEMBERS OF THIS COMMITTEE IN AN EFFORT TO REVERSE OUR SLIDE IN EDUCATION. I ALSO WANT TO THANK THE WITNESSES FOR SHARING THEIR EXPERTISE AND TIME WITH THE COMMITTEE. WITHOUT THEIR GUIDANCE WE COULD NOT SUCCEED.

The CHAIRMAN. The Chair recognizes the gentleman from Pennsylvania.

Mr. WALGREN. Thank you, Mr. Chairman. The concept of this stimulus that you speak of that the Federal Government should give, and one of the analogies was the G.I. Bill. Now the G.I. Bill was a massive, massive funding effort, I gather, and that is not exactly what I would term some small stimulus. That was a downright injection right into the heart of the stimulus, wasn't it?

I was just curious. Why did the university presidents resist it then?

Dr. NEWMAN. They named three things, if they look at the testimony. One was that it would bring back on the campus a bunch of people who had been off in the service and were killers and so on, and it would be disruptive on campus.

Second was that it would bring back a lot of people who had different interests and abilities and would dilute the quality of the campus. And you've got to remember that this was a time in which we weren't nearly as selective about college. It was what family you came from rather than how good your scores were.

Third, and certainly the least understandable was that it would bring back to the campus some people who were married and therefore would not have time to study. Now that shows a true lack of understanding of students. I was a G.I. and I wasn't married, and my problem was that a consequence of not being married, I didn't have time to study.

[Laughter.]

Meanwhile, those guys who were married, of course, were running circles around us.

[Laughter.]

Mr. WALGREN. Well, I just want to put that on the record just to think about it, because I had never understood them to do that. I had not known they had taken that position, and it is interesting how stuck in our ways we get.

You talk about teacher retraining. And we say, gee, as my colleague from Pennsylvania says we don't teach them much about how to teach in teacher retraining. I guess my question is, we had a witness from a teacher retraining course in California who was extremely excited about its potential and its success, and what he was doing was, he was not teaching them how to teach, not even teaching them what to teach. He was particularly focused on science, essentially, and he was bringing and teaching them science from the start and that struck me as sort of strange, because it is a long way from A to B, if you are learning physics from the start as opposed to some good experiments that you can do that make certain points.

How do you see teacher training? Is there one mold at this point that we could pick, or are you feeling as you indicated, that you could get a great variety of suggestions from States that we should be funding as a stimulus?

Dr. NEWMAN. Well, first, I don't think you can get, in the United States system—remember, we have a diffused authority system. There is not a national system of education in the United States. Education is controlled at the local school district and at the State level. There are 54 States and territories, and there's 15,000 plus school districts, and there is 110,000 schools. And there is no way that you can mandate the same way of teaching everywhere. What you can do is make sure that good ways spread and that the right principles get in there. I think the teaching of math and science requires something that you are talking about.

If you want people to teach in ways that students learn to reason, then the teacher must have the self-confidence to engage the student in a serious dialogue. If the teacher really does not understand the subject well, the last thing the teacher is willing to do is engage the student in a serious dialogue. So one of the things there must be is self-confidence on the part of the teacher about knowing the subject. And one of the things that we have as a problem in math and science is, we have a lot of people who have gotten into math and science teaching who are not really grounded in either math or science.

Mr. WALGREN. When you say give the system the capacity, I think you used the word capacity to make things happen. One of the things about the Los Angeles system is that the teachers were paid, it was a summer program, and it was a very intensive program, but they were paid to engage in that, and the implication was that they would not have had the capacity because of the need to continue their income flow, had there not been the support there to pay them to do it.

The same thing is true in Pittsburgh, as I understand it. They bring them in there in a sense on a kind of extended sabbatical of several months or something, but they pay them.

Dr. NEWMAN. What they do is, they provide the money for the replacements.

Mr. WALGREN. Right. Right.

Dr. NEWMAN. And the same is true in South Carolina, which has a very interesting system of retraining all its teachers.

Mr. WALGREN. So to a certain extent, we've got some expense here, but on the other hand, am I reading you correct in saying that our problem is not really to tell them what to do, that there are good proposals that could come forward, and even with respect alternative teaching tracks, there is much that remains in the State domain, and we could allow things to happen, but I don't sense you saying that from the Federal level we should be deciding what should happen.

Dr. NEWMAN. That is exactly my point, Congressman. If this committee were to say here is the one way that teachers should be retrained, you can guarantee it won't work. Why? Because everybody out there, sitting out there is going to say, wait a minute. We know more than you do about this. What are you doing there sitting back there deciding how this—people have to buy in.

Let me give you an example of how I thought very cleverly South Carolina got its school districts to buy into the process of teacher retraining. What they did was they examined the research and found nine different types of programs that they thought worked well, and the research proved they worked, because there are some retraining program that don't work very well and others that work a lot better. So they went to every school district and said we will fund you to retrain your teachers. You can choose any one of these nine programs, because the research proves they are effective. It is up to you to pick the one you want or you can design your own program. All you have to do is prove to the Department of Education that your program meets, by the research criteria, what works. But it is up to you.

Of course, what happened as a result was school districts began to argue about which was the best method. Well, now you've got them arguing about whether you want number 4 of number 7. And school superintendents were arguing with each other, and one would say, well, we're taking 4 and the other fellow would say, taking 4. That's the dumbest move I ever heard.

Well, now you've got people buying in and you've got an assurance of success. There's got to buy in, or there isn't assurance of success. And I thought what was so clever about it was that the governor had maneuvered them into a position that they were all arguing about which-one to choose, but from his point of view, what difference did it make? As long as they chose one that he knew would work, and they weren't upset about the process of retraining their teachers, he was happy.

Mr. WALGREN. Yes. We face this problem in the Congress between the National Science Foundation and the Department of Education. Traditionally, the National Science Foundation was the first Federal agency involved in science education, and in the 1960s, there were very broad spread teacher retraining programs and many of the teachers wonder where they went, because they essentially were phased down and out through the seventies. But traditionally, the National Science Foundation has been the funder of teacher retraining programs in science, in any event.

You mentioned your interest in these competitive proposals, and that is very much along the line of the National Science Foundation model.

Do you have any guidance to us as to how to run these programs on the best level between the National Science Foundation and what the Department of Education can bring to it at this point?

Dr. NEWMAN. Well, that is an interesting question, because, of course the question of teacher retraining has traditionally—I mean, you've got two different components, the science and math side, which is in the National Science Foundation, and the straight teacher retraining question, which is really in the Education side. As a matter of fact, we have recently begun some serious discussions of both of them, because, frankly, in our opinion, these issues are connected. If you are retraining a teacher in order to be an effective science teacher, and that teacher needs to learn science, that is very important, but that teacher also, at the same time, ought to be learning more about how to teach in ways that are effective in getting science across, and that is really part of education.

I think there is a willingness on the part of both those agencies to talk in some common terms. At least they are talking to us in common terms, and I am hoping we will soon have a national program on this front that might combine those two, working with them.

Mr. WALGREN. Thank you, Mr. Chairman.

The CHAIRMAN. Further questions? The gentleman from California, Mr. Packard.

Mr. PACKARD. Thank you, Mr. Chairman. A few years ago, there was a significant emphasis on science and math and several other areas with the "Nation at Risk" report.

Have you felt that there has been improvement since then, or was that a big push that ended up going nowhere? Are we back where we were? Are we worse than we were then, or has there been progress?

Dr. NEWMAN. Oh, I think we have made considerable progress. There is one thing that is left out, but we have made considerable progress. Test scores are up. Much more emphasis on education. All kinds of things, and some side effects have happened as a result of the pressures that came out of "A Nation at Risk" and the terrific interest in school reform that has been going on.

One of the side effects, for example, is the amount of homework that is being done by school children—the National Assessment for Education Progress had been measuring this—has approximately doubled. Now there isn't any law that says more kids have to do homework, although several States that I know of would have cheerfully set about to do it, but the fact is that all the emphasis on it has led to that doubling. What hasn't happened is the National Assessment has also shown test scores have gone up, but reasoning skills and thinking skills on the part of students have not improved.

So we have made progress, we've gotten much more sophisticated. Good things have happened, but we are hardly there.

Mr. PACKARD. Are we closing the gap with foreign educational systems?

Dr. NEWMAN. Well, one of the problems with closing the gap, we have closed it in certain ways, but in other ways we haven't narrowed it much. One of the troubles with closing the gap is that—this discussion you are having here is mirrored in every other industrial country in the world. I was in Japan very recently for a conference on how do we restructure the Japanese universities in order to improve their quality. They are nowhere near as good as the United States. I was in Europe just a short time ago in Turkey for a meeting on how do we improve the quality of Turkish education. They had the European educators there. There was one in Paris just a short time before that.

Everybody is doing the same thing. So we are struggling to—it is not that there is a golden level we can reach and then we will be there. They are trying to advance as well. It is as if you were in the computer business, and you were behind some Japanese competitors and you got a new computer out, and you said now we have caught up with them; we can go back to sleep. No way. This is going to be the steady problem from here on out. So we not only need a system that is better but a system that has built in incentives to keep improving itself. And that we haven't got.

Mr. PACKARD. The so-called "new math" system that we have had now in place for a couple of decades perhaps, how do you evaluate that and whether it has been effective?

Dr. NEWMAN. Well, it is not as big a failure as everybody says. There are some good things that came out of it, but basically, it was not a successful effort, in my opinion.

Mr. PACKARD. Have we reverted back to a different math system?

Dr. NEWMAN. Well, it had the disadvantage exactly what we are talking about, that you can't have one centrally designed approach that everybody is supposed to follow. I think there are lots and lots of ways of teaching math or science that are very effective, some wonderful, very explicit systems, and there were some wonderful general approaches. I think that that system had some flaws in it, it got centrally decided, it was imposed out there, it didn't work all that well, and we didn't have the capacity built in to keep modifying and improving it, because it wasn't generated in a way that the schools had a stake in it.

Mr. PACKARD. How interrelated is math and science? Are we able to make progress in one area or to concentrate on one area without concentrating—

Dr. NEWMAN. You mean math or science?

Mr. PACKARD. Math and science. How interrelated are they?

Dr. NEWMAN. Oh, they are extraordinarily related. Not only that, but they are interrelated to something else that we haven't got through our heads yet. They are interrelated to the ability to think, and whether kids are going to be—

and this gets back to what you said, Mr. Chairman—whether kids are going to be involved in a high tech industry, and that has nothing to do with it. You've got to learn to think in the modern world. And being able to reason in mathematical terms or in scientific terms is part of thinking. It is the best way to learn to think. And we let that slip away for a whole group of people.

See, one of things that—since many parents, well- educated parents, never realized mastered science or math, they accept the idea that all kids don't have to know science or math. I don't know if you saw the—you know, the Miss Peach cartoon strip? They have a little cartoon where Ira, the kid, is in front of the principal and the principal is saying to him, "Ira, your mathematics grades are terrible. I am going to have to call in your parents." And he says, "It won't do any good, they too are lousy at math."

[Laughter.]

And we have been saying this for ourselves. We are excused. I didn't have to learn math, so it's okay if my kid doesn't have to learn math. Not true any more. So math and science are much interconnected with each other. You have to learn both skills, but in addition, they are connected to every other damn thing. So you might as well recognize that all school children can learn math. We haven't believed that. We believe a lot can't learn.

I'm sure you've all seen "Stand and Deliver," the film about Jaime Escalante in Garfield High School. It's a true story. This teaches comes in and takes bunch of punks and teaches them advances math. Well, there are thousands of examples of this. Kids can learn math and they can learn science. We just don't believe it, and we haven't believed it's important. Now it is important.

The CHAIRMAN. I thank the distinguished gentleman.

Are there additional questions? First, the distinguished gentleman from Texas, Mr. Smith.

Mr. SMITH OF TEXAS. Thank you, Mr. Chairman. I'll make it brief.

Dr. Newman, I appreciate your testimony. I especially appreciate the latter part where you made specific suggestions for curriculum improvements, because I think we have to be solution-oriented, and I think we have to go into the schools and make changes there.

My very brief question for you, basically is, what can the Federal Government, what can we, as Members of Congress, being doing? You may be familiar with some of the bills that have been introduced, which I happen to support, you know, doing some substantive things such as giving scholarships rewards to top science students in Congressional districts, and so on. If you haven't already before I arrived, please comment on those kinds of bills that are in Congress, and if you think that they will help encourage more emphasis on the science math.

Dr. NEWMAN. Yes. I haven't had a chance to comment on that. I do think those will help. There's, I think, a double problem in this whole thing. One is what I was just saying a moment ago, we must have changes in the basic structure of the schooling district, in which we convince ourselves that we are going to and can succeed in teaching all kids math and science. We haven't made that decision in our gut. But the second thing is, we must find ways to encourage some of the really good math students to go on in these fields. You know all the statistics, how badly off we are in terms of the percentage of students.

So I think things such as those math and science scholarships are excellent modes for doing that. There are several State versions of that and they work wonderfully.

Mr. SMITH OF TEXAS. Okay. Great. Thank you, Mr. Chairman.

The CHAIRMAN. The Chair recognizes the distinguished gentleman from Tennessee, Mr. Tanner.

Mr. TANNER. Thank you very much, Mr. Chairman.

Just one quick question, Dr. Newman. What is your observation about the career ladder in Tennessee? You mentioned that. I was there during that time, and I would like to know how you think it is coming.

Dr. NEWMAN. Well, you know, there's a lot of struggling going on about it at the moment.

Mr. TANNER. Yes, I realize, yes, sir.

Dr. NEWMAN. And a lot of concern. I think we've got a lot at stake in this country. I happen to be a believer in career ladders. I do understand the forces about egalitarianism within the teaching profession and all that sort of stuff. I frankly think a career ladder is a good solution to that as opposed to a merit pay system. It is more like the higher ed system, where you can get to be a full professor and you are still a teacher, if you know what I mean.

Mr. TANNER. Right.

Dr. NEWMAN. So I am in favor of it, and I think the Tennessee case is an interesting case, and I hope that it turns out that in Tennessee it persists and grows and improves.

Mr. TANNER. We've had an enormously difficult time with the merit pay because of the subjectivity involved that one cannot avoid, I don't think. But be that as it may.

There was an ABC documentary called "Losing the Future." Are you familiar with that?

Dr. NEWMAN. Yes. I saw only parts of it, but we had a lot to do with ABC's putting it together.

Mr. TANNER. Two things came out of that. One, just the amount of time in the classroom. I think the Japanese children go something like 220 to 30 days and we 175, 180.

Dr. NEWMAN. 180 is top.

Mr. TANNER. Could you comment there?

Dr. NEWMAN. Well, clearly, we would be better off if kids went to school more. The Japanese not only go to school more, but of course, they go to cram school after school and cram school on Saturday. I think the Japanese overdo it. The Japanese think the Japanese overdo it. They don't know how to get out of doing that. But we are underdoing it. It would make a lot of sense for this country to have a longer school year and to start school earlier in the morning and end school later in the afternoon.

The second point, starting school earlier in the morning and ending later in the afternoon is probably going to creep in. We already have preschool problems and afterschool programs. That is coming about because so many families have two parents working and the kids are now at school for longer periods, but amazingly, in spite of the fact that there are so many families with two parents working, parents are the ones that have opposed longer school years. You would think that they would be fully in favor of it, but that is where the real opposition is coming from.

Mr. TANNER. Thank you, Mr. Chairman.

The CHAIRMAN. The Chair recognizes the gentleman from Alabama, Mr. Browder.

Mr. BROWDER. Thank you, Mr. Chairman.

Dr. Newman, in Alabama, I was a sponsor of a career ladder law that was unlike most of them. I think it may have been unique in the country. It was supported by the teacher organization. But let me share this with everybody. That didn't work either. So that is not the only solution.

Dr. NEWMAN. Well, there's two or three that are working. I am trying to remember them off the top of my head, but there are two or three that are working pretty effectively at the moment.

Mr. BROWDER. I think it can work, but I think it is very, very, very difficult.

Dr. NEWMAN. But only because of the culture of the schooling system.

Mr. BROWDER. Right.

Dr. NEWMAN. I mean, we do have career ladders in effect and merit pay at higher education, and that's a different culture. It's the only reason it works there and doesn't work at the other.

Mr. BROWDER. Because of the culture of the school system and the political environment, I found to be very important. But I also sponsored the legislation dealing with science and math in service centers. That I think has been very, very effective.

But you've asked us to go to start a crash effort, but a thoughtful crash effort. Let me ask you a question. You know, we can talk about the problems of science and math education, but the fact is, you're talking to the Members of the United States Congress. As you said in your comments, we do not need to go about another crash program, a top down crash program. The problem is there. It must involve States and school districts. You know, the Federal role is relatively small in money. In money. It is relatively small in money. How do we go about providing a crash program that stays away from the political meddling but also recognizes that in terms of money we have a relatively small role? Two-part question.

First, what types of Federal programs do you think have had the most significant impact or represent the most opportune direction for us to go in. Also, what direction or counsel would you have to us here. Recognizing our relatively limited role, what direction or counsel would you have for us as far as the Federal role is concerned?

Dr. NEWMAN. Well, first, you are absolutely right, the money in elementary and secondary is something like six percent, and the State governments put up 51 percent. So that is a big difference. Also, most of the policy is made here. But I don't think the Federal Government has a small role or a limited role in terms of initiative. I think it has proven over the years to be an extraordinarily effective effort—center of initiative. I think there are four or five ways you exercise that.

Demonstration programs. Head Start is a good example. It wasn't intended as a demonstration, but it is a damn good example. Head Start proved that early childhood education worked.

Second, research. The research on Head Start demonstrated that in fact it was working. If it hadn't been for the research that the Federal Government funded about the Head Start program, we wouldn't know that early childhood education was so important.

Third, matching grants. You can get almost any State to do almost anything by a matching grant.

[Laughter.]

As a matter of fact, a small matching grant will get any educational institution to do anything. We are totally independent. We will not be bought, but if you've got a thousand dollars, we'll talk about anything.

[Laughter.]

We've been helping a couple of States with a really interesting set of competitive grant programs. In one State, Colorado, we are doing it with $5000 grant programs, where school districts are coming in and putting together fantastic programs. Well, you know, the average school district in Colorado probably spends ten million dollars, and here a $5000 grant is getting a lot of action.

So you can get States with a—seed money programs are good examples. Competitive grant programs. You've got this new First agency, which is prepared to make competitive grants. If you put out competitive grants and said we are interested in States coming in with exciting teacher training programs. There are a hundred ways to do this, but here are our criteria. We want these teacher training programs focused on the capacity to teach people math and science, fundamentally, and so on and so on. We want to be able to teach in a reasoning way, not just a rote-learning way, and so on and so on. Bring in your competitive proposals, and they will be judged by this group of experts. You are going to get a major response on the part of the States.

So I think the Federal Government has the capacity in it with small amounts of money to create massive amounts of initiative.

Mr. **Browder**. Thank you. Thank you, Mr. Chairman.

The **Chairman**. The Chair recognizes the gentlelady from Maryland, Connie Morella.

Mrs. **Morella**. Thank you. Dr. Newman, speaking of Japanese education. I was reading that the Japanese have actually established some schools here in the United States.

Dr. **Newman**. One in Tennessee.

Mrs. **Morella**. Right. Because they feel that the American schools, despite any language barrier, and they don't really have much of a language barrier, just are not preparing their kids to be able to compete to go to college, which is the big thing in Japan.

Dr. **Newman**. You bet.

Mrs. **Morella**. And it seems so ironic that they feel that our schools are inadequate but our colleges and universities are not. That is where they come back in and our students do not. There are a lot of innovative things. I just wondered about your feeling about them.

In my area, I have heard about a program, I don't think it is done very widely, where, let's say, in high school, students taking chemistry can go into an elementary school, which is where I think it all begins, and teach these kids chemistry. So students teaching younger students. Therefore, they learn, because they are teaching and the kids can empathize more with someone else's student.

Secondly, the concept of magnet schools. I don't know that you have addressed that. Science, match magnet schools. I wondered about your opinion of some of those programs.

Dr. **Newman**. Both of those, I think, are not only important, but very important. For example, on the mentoring, using high school kids or even middle school kids to mentor. We have a major program on getting college kids to mentor. It is called Partners in Learning. It is shared by the governor of Minnesota, and we've got a consortium of universities and colleges all over across the country who have agreed to get their students into mentoring at risk kids, because in every one of these things, the problem, particularly at the bottom end of the spectrum, kids that are doing badly, the big problem is that they don't have confidence in themselves, and when someone mentors them, it does wonders, but it also does wonders for the mentor. And you are suggesting, why not do—Or there are some programs doing that in math and science.

I think it is a terrific thing, and I think it helps both the students learning and the mentors themselves who become—no one wants to be embarrassed. You are about to go out and teach some elementary school kids how to do some scientific experiments, you know that kid for the first time probably ever is really going to do some intensive homework. I've got to go do that tomorrow, so boy, tonight I can't watch television. I've really got to go at this.

I am just strongly in favor of that.

The President has a team working on whether or not they could put together some sort of an idea on mentoring. It's not focused on math and science; it's focused on getting at risk kids up to grade level in all subjects.

Mrs. **Morella**. When you talk about self-confidence and sense of inferiority and whatever, it took a great deal of courage on the part of the defensive back, Dexter Manley, of the Redskins—

Dr. **Newman**. He's a lineman, not defensive back

Mrs. **Morella**. Right—when he appeared before the Senate Committee on Education and said how he had flunked in elementary school and how he finally learned how to read.

That is another thing we are contending with too, is that people who have been compensating for lack of just being able to read, to understand beyond, you know, fifth grade level. What surprises me in the whole ordeal, and I commend him highly for what he did, and he's a great example, how in heck did he get out of our school system and out of our college?

Dr. **Newman**. Yes. And out of a university. That's the sad part.

Mrs. **Morella**. Yes. Or even a secondary school.

Thanks, Mr. Chairman.

The **Chairman**. The Chair recognizes the distinguished gentleman from Idaho, Mr. Stallings.

Mr. **Stallings**. Thank you, Mr. Chairman.

Mr. Newman, I also was a teacher, taught several years in the public years and a few years at the college level. I remember a number of years ago a speaker coming before a group of teachers and telling us that he had a solution to the Third World population problems. The solution was to take American science teachers, and I think he has also included English teachers, send them into the Third World and have them teach sex education, and then the results would be the same as it is in this country, they would all lose interest, and that would solve the problem.

[Laughter.]

I think there may be something to that.

It was my observation as a public school teacher, and I haven't found this in your testimony, but I heard someone make reference to it, that salary was not a great compelling issue. I have to differ with you. In my five years in the public high school, we would lose about a third of our teachers every year. They would come in from colleges; they would be excited; they would do a tremendous job for the first year or two, and then you would start seeing some burnout. They would find themselves forced to take evening jobs, find themselves forced to do other things during the summer, and after a while, that offer from industry started looking awfully good. And when a person could move from the classroom into a corporate office and double his salary, plus faced with the burnout from dealing with, not so much the classroom problems, but dealing with a lot of the administrative details, dealing with attendance and restructuring classes so there could be a pep rally or whatever was happening. They just got tired of it and tired of facing the frustration of it.

Someone also made the statement that there was some opposition from teachers for year-round schools. I did not find that to be the case. I found teachers very supportive of it. I found that they had a profession, they would like to work that profession year round rather than just a few months during the fall and winter.

I agree with the comments made regarding the teacher education programs in the colleges. They are make-work for both students and perhaps faculty that perhaps ought to be doing something else.

I think that the bottom line to all of this—this still comes back to funding—giving people a standard of living where they can do what they want to, and that is teach. My state, Idaho, is one of the lowest in teacher salaries. We have some compensation things going on there. That is, the environment people will come to Idaho and work for several thousand dollars a year less just because they want to stay in that kind of environment, but again, it doesn't last. It is not a lasting thing. So unfortunately, we get the problems in the classrooms that are not going to go away with a few seed programs from Congress or a few awards from the White House. The problems are much deeper.

Now we are trying a few things in Idaho, and that is some satellite education. We have dozens and dozens of very small school districts that can't even begin to compete for competent science, competent math teachers. I mean, you get a small school district of maybe 200 students in the entire district and maybe eight kids in the senior class. There is no way that you can hire a first-class math teacher to come to that school and teach that plus the seven or eight other subjects that he would have to teach just to maintain a faculty position.

What are the tests showing on the television-satellite kinds of teaching?

Dr. NEWMAN. Well, can I just go back to something you said. You mentioned the question of year-round schooling being opposed by the teachers. I didn't say that. What I said was that the parents had opposed it.

Mr. STALLINGS. Okay.

Dr. NEWMAN. And that continues to be the case. I am always amazed at that, because it seems to me that parents would have a stake—since both parents work and can't take three months of vacation, you would think they would have a stake in having the kids be in school, since it is: (a) good for them, and (b) it solves some of the parents' problems. I think that will begin to change.

Secondly, in terms of salaries, obviously, what we are talking about here is only part of the overall problem of the education system in the United States and, surely, better teacher salaries would be a positive thing, but they have, over the time of the education reform period, the last six or seven years, they have gone up about 30 percent in real dollar terms in the United States. So that is an improvement at least. My argument is, I have been on the Metropolitan Life Foundation Board, and we have been the ones running these teacher surveys, and they show that the teachers care a lot about money. I don't mean to say—there are only one or two groups that I know of in the world, Congressmen and maybe one other, that don't care about money, but everybody else, sure, they care about money. I don't mean that.

What I mean is, that they care even more to be in a system that values them, as does anybody. People want to be in a system where they are valued, they are part of it, they contribute to it, and so on. Some of the tests of schools that have been restructured, turned around, where teachers are playing a major role, you tend to lose very few teachers from those schools, because they get excited about it.

In terms of the satellite learning, it is still kind of early, because we haven't had a lot of years of that, but Idaho is certainly an interesting case. Most of the mountain States now are pretty far along it this. I think the results so far, the preliminary results, are very encouraging. And I think you are going to see that now that satellite links are everyday business in this world, a piece of cake, I think you are going to see a lot of that, and I think it is going to turn out that with those classes, they will be just as effective as having the teacher there.

Mr. STALLINGS. Thank you.

The CHAIRMAN. The Chair recognizes the distinguished gentleman from New York, Mr. Boehlert.

Mr. BOEHLERT. Thank you, Mr. Chairman. Before anything, I would ask unanimous consent that an article in yesterday's New York Times, OpEd piece by Linda Darling-Hammond, entitled "Boosting Our Scientific Future," be included in the record for all to see.

The CHAIRMAN. At this point; no objection.

[The document follows.]

THE NEW YORK TIMES, SUNDAY, MAY 21, 1989

Boosting Our Scientific Future

By Linda Darling-Hammond

WASHINGTON

Shortages of qualified mathematics and science teachers have bedeviled the U.S. for the past 30 years. Although various initiatives to encourage potential teachers have been launched in recent years, they suffer from a short-term perspective.

Indeed, it will be impossible either to boost the supply of teachers or the level of math and science competence without a sustained effort to upgrade conditions for teachers and to create incentives for them to remain in the profession.

Ever since the launching of Sputnik in 1957, Americans have periodically wrung their hands over the sorry state of math and science education. In the last few years, a new spate of studies indicating that both children and the population at large are "scientifically illiterate" and "innumerate" has precipitated another bout of hand wringing.

A survey by the National Science Foundation, for example, found that only 6 percent of Americans could be termed "scientifically literate." And in several international assessments, American high school students have continuously ranked near the bottom of the list, below those of other industrialized nations.

Without incentives, the shortage of good teachers will worsen.

While scientists and policy makers are concerned about these trends, too little attention has been paid to one of the major causes of the problem: The shortage of qualified teachers.

Even though employment in engineering and the sciences doubled between 1976 and 1986, the number of degrees awarded by universities in math and sciences was stagnant or declining. Furthermore, a growing share of these degrees (20 to 40 percent) was awarded to foreign students, many of whom return to their countries.

The reasons for teacher shortages are not difficult to understand. While beginning teachers earn about 25 percent less than college graduates in other fields, math and science teachers must swallow wage disparities of 30 to 50 percent. These differentials grow even larger over the course of a career.

Although teaching offers attractions to those who love to work with children and enjoy summers off, the working conditions generally leave much to be desired. Long hours with relatively low pay and little prestige are compounded by the lack of an office, telephone, typewriter and secretarial help, not to mention teaching materials and lab equipment.

These conditions contributed to a 60 percent decline in newly prepared teachers from 1972 until 1985, and they continue to spur high turnover rates among beginning teachers. At present rates, graduates from undergraduate schools of education could be expected to fill about half of the 20,000 annual vacancies for math and science teachers.

A number of initiatives to attract persons from other fields have been launched. These include nontraditional preparation programs aimed at easing the transition for midcareer changers or retirees through financial aid, flexible scheduling and concentrated course work. They range from intensive graduate-level programs to alternative certification programs designed to get recruits into classrooms with as little as six or eight weeks of training.

A Rand study of these nontraditional programs found that they are training several thousand new math and science teachers each year. However, not all of the programs are equally effective. The quality and intensity of preparation make a difference in how well prepared recruits feel and how long they plan to teach. Among the graduates surveyed, 75 percent were teaching an average of two years after graduation. Of that group, only half envisioned a permanent career in teaching.

While easing access into teaching can help, increasing the attractions — and providing adequate preparation — are critical. Though President Bush recently announced a program to provide $25 million for more flexible certification, the proposal would make little difference unless the funds are invested in serious training.

We need something like the Health Professions Educational Assistance Act of 1963. That act addressed critical shortages of physicians with a large-scale infusion of scholarships and student loans, assistance to medical schools for improving curriculums and training and incentives to induce doctors to prepare in shortage fields and locate in underserved areas.

Now, 25 years later, we can boast of the highest quality medical care in the world. We should do no less for our scientific future. □

Linda Darling-Hammond is co-author of a Rand Corporation report on recruiting teachers.

Frances Jetter

Mr. **Boehlert**. And secondly, Dr. Newman, I agree with you that kids can learn math and science, if we have the teachers to teach them. And that is one of my great concerns, and that has been brought up by a number of my colleagues this morning.

One of the things that I'm enamored with is an incentive program which is embodied in a bill that I have that is moving its way through the legislative process with the support of our distinguished chairman, which would provide $7500 stipends for juniors and seniors during their undergraduate years, who are majoring in science, math and engineering, in return for a pledge that they would teach two years for each year of the stipend.

Now I would like to know your reaction to that proposal.

Dr. **Newman**. Strongly positive. A few years ago, I wrote a book called "Higher Education: The American Resurgence," and it has a proposal in there called "The ROTC for Teaching." And it is almost exactly what you are talking about. If we are short of people particularly in teaching, particularly in math, science teaching, why not take a program that has worked extraordinarily well for us, the ROTC program, which works much better than loan forgiveness. Your mode is much better than loan forgiveness. Loan forgiveness has the disadvantage—college students—this may surprise all of you, but college students don't often think thoroughly about what is coming in the future. I know that is a terrible thing to say.

[Laughter.]

What they tend to do is, they sign up for something, say, aw, yeah, great, great, and so on, and then finally they get around, and they say, well, gee, wait a minute, a minute, I don't really want to be a teacher.

ROTC has the advantage that the student comes to the campus, joins ROTC, gets the scholarship, but right away, you put the uniform on and you start your weekend training, and if you do the same thing in your proposal, you sign up, and you start getting weekend training in teaching, and you take your summers and take your—suppose, for example one of the requirements was during the summer you took a group of 25 kids that are behind grade level, and your job was to get them up to grade level in math and science, and by the time that person becomes a teacher, they know about teaching, they've got experience, they've got first-class hands-on experience. We did a lot of research talking to the military about what happens in this kind of a program.

One of the things we said was, do ROTC officers tend to dog. You know, they've got four years they've got to go in the military. They said, no. Surprisingly, ROTC officers always ask for the most exciting and dangerous assignments. They want to be paratroops and Green Berets. We said why? They said because those officers say I am not going to necessarily be here forever. As long as I am here, I might as well accomplish something.

So I think your proposal is terrific, and there is—

Mr. **Boehlert**. You'll be hearing more from me.

Dr. **Newman**. Okay.

Mr. **Boehlert**. We hope to be hearing more from you on this proposal too.

Dr. **Newman**. You might very well want to look at Jefferson County, Colorado, just outside Denver, which decided to do this on its own. It now funds kids through college on the condition they come back and teach in Jefferson Country.

Mr. Boehlert. Which leads me to my next question. And thank you for that lead in.

Are there any particular programs at the State or local level that you think are so good that we should consider replicating them on a national level?

Dr. Newman. You mean of the kind you are talking about?

Mr. Boehlert. Precisely.

Dr. Newman. Jefferson is the only one I know of that has actually implemented it, but there are, I think, three States that have them in the mill. I can't remember the States offhand, but there are three or four, and I will get you a list.

Mr. Boehlert. Okay. Fine. I appreciate that very much.

Thank you, Mr. Chairman.

The Chairman. The Chair recognizes the gentleman from Virginia, Mr. Slaughter.

Mr. Slaughter. Thank you, Mr. Chairman.

I would ask, Dr. Newman, in the fields of science and engineering and mathematics, isn't it pretty well agreed upon that we need a steady flow of students through the graduate level, if we are to maintain our competitiveness?

Dr. Newman. Absolutely. And we're way too low

Mr. Slaughter. Yes. Now I have a bill along with Congressman Walgren and Congressman Boehlert that has been discussed here this morning, but one, the National Science Foundation, as I understand it, has been engaged in making grants, deciding on who gets grants under certain terms, and so forth. Would they not be a natural agency to handle encouragement and grants to college students and possibly in the future, graduate students in these fields?

Dr. Newman. Yes, in fact, that was one of the first things the National Science Foundation did when it was first started in 1950.

Mr. Slaughter. Yes; right. Thank you very much.

The Chairman. If there are no further questions, we want to thank you very much.

We will have some additional written questions, if you don't mind, we will submit them to you for your observations, and it would be helpful to the committee.

You have been a splendid witness, and we appreciate your being with us this morning.

Dr. Newman. It's been fun.

The Chairman. Thank you very much.

Dr. Newman. Thank you, sir.

The Chairman. Now our next witness for the day is Dr. Victoria Bergin, Texas Deputy Commissioner of Education for Curriculum and Program Development, Austin, Texas, and I believe we have with us, Dr. John J. Murphy—did Dr. Murphy get here? Your plane landed, I see—New York Assistant Commissioner for Education for Elementary and Secondary Planning, Testing and Technology Services, from Albany, New York.

These panels have been structured for the benefit of the members to now get an overview or response in effect from hands-on experience that both of you have had in your respective States. Therefore, the chair recognizes the distinguished gentlelady, Dr.

Victoria Bergin. Both of your statements will appear in full in the record, if there is no objection, and in those instances, you can summarize or proceed at your leisure.

Dr. Bergin.

STATEMENT OF DR. VICTORIA BERGIN, TEXAS DEPUTY COMMISSIONER OF EDUCATION FOR CURRICULUM AND PROGRAM DEVELOPMENT, AUSTIN, TEXAS.

Dr. **Bergin**. Chairman Roe and members of the committee. Thank you very much for the opportunity to speak before you. You do have copies of my written testimony, and I only wish that I had an opportunity to answer some of the questions. I was sitting behind Dr. Newman and just dying to jump right in with responses.

What I will do is summarize my written testimony by offering you an outline of the major steps that we took in Texas as part of our school reform movement and specifically in the areas of mathematics and science education.

In the late 1970s, Texas found itself, as many other States in the Nation did, with a very dismal track record of student achievement, particularly in the areas of mathematics and science. We found ourselves with a very fragmented and a very low level of instructional programs, students that were dropping out of school and those that remained in school, a very, very small percentage of them were going into the advanced math and the advanced science courses.

As result of that and as a result of a great deal of public testimony and criticism about the public schools, we emerged on a two-phased school reform movement that began in 1981. Because Texas is a very varied State, we have almost 1100 independent school districts, and school districts pride themselves on the independent label that is attached to them, we took the three-pronged approach, because first of all, we felt that there were some things that must be done at the State level where you have to say some things, take certain positions, establish some priorities.

So the first approach had to do with legislation and top down reform. However, at the same time, we realized that we also had to honor the independence of the school districts and that reform or change that comes from the grass-roots empowerment is always the most long-lasting.

The second prong of our reforms also acknowledged the grass-roots approach and left it open for exemplary programs to come up from the grass roots.

Thirdly, because reform is something that we had hoped would not change every two years when there was a new legislative session, the third prong of our approach was long-range planning to determine where we wanted to be in the 21st century and to define the steps that it would take us and setting our priorities year by year to get us to the 21st century.

So with that as the background, let me just describe some of the main highlights of what we did in each of the three approaches.

Number one, legislation or top down reform. Probably the most significant thing that we did in Texas is that we went through a massive curriculum reform where we established what, in effect, is a State-mandated curriculum for the State of Texas. Kindergarten through grade 12. And within that curriculum, we established priority areas beginning at the kindergarten level and including mathematics and science in the kindergarten level, moving all the way up to graduation, and within that curriculum, what we did at each grade level is, number one, we said there are certain essential elements at each one of these grade levels that must be taught, must be taught at those grade levels.

And how do you establish the priorities in the content areas?

One way at the end of the spectrum is through graduation requirements, and we would include in graduation requirements those courses which we felt were priority areas for all the students to end up with the content of those courses at least under their belts by the time they came through 13 years of our system.

At the lower grade levels, how do you establish priorities? And the way you establish priorities is through time. How much time should be allocated on a daily or a weekly basis to a particular content area.

As a background to what the priorities are, let me point out to members of the committee that there are approximately 360 instructional minutes in a school day. That's it. 360 minutes. And there is a tendency on the part of the public to want to lay on more and more and more within the structure of those 360 minutes, and therefore, what happens at the school level, at the classroom level is either some things are left out or everything is watered down. And in determining the essential elements, what we wanted to do at the State level is to say that no matter how much you want to teach folk dancing or what your favorite projects may be, there are certain things that you much do in the third grade, because the student must be exposed to that before the student moves on to the fourth grade.

So with that, we did establish in the math and the science areas two very strong priorities that at the elementary level, mathematics would be taught for the equivalent of 60 minutes per day, science for the equivalent of 45 minutes a day. And that was a tremendous shock to our public school system, because the research that we had done up to that point suggested that in some classrooms across the States, if mathematics was taught 15 minutes a day, we were lucky.

So that was one thing. Establishing the essential elements of the curriculum and priority areas for teaching.

I noted that in one of the comments that was some of the written testimony that I had read that the fact that at the ninth grade level our students who take algebra in the United States score the lowest in a international comparison, and I would posit for that that what we found in our own State when we looked at algebra instruction is that in some cases, in some classes, it truly was algebra instruction, but in other classrooms, it was somewhere in the neighborhood of the equivalent of fifth or sixth grade math instruction, but it was called algebra 1.

So what we did with the curriculum was to say algebra 1 is this, and this is what must be contained in it, and if you are not teaching that, then you are not teaching algebra.

Along with that, we moved into our accountability process and as part of the accountability, the school monitoring of districts, which takes place on a cyclical basis, the question that was asked of all campuses and of all districts is, are you teaching this curriculum and how many of your students are, in fact, taking algebra, calculus, trigonometry, and if they are not taking those courses, why not, and what steps are you taking in your school district to move a larger number of students through that curriculum.

So that was part of giving the visibility to mathematics and instruction and increasing the graduation requirements in those areas.

Having laid that down and having said that this will be the curriculum and you have three years to work your way into that, then we began looking at the local level and empowering the local district and the local campuses towards meeting that curriculum, and how they did it was left up to them, how they taught that curriculum, the methodologies that were used, the structured within the school day. That was left up to the local district, and in order to encourage unique approaches and creative approaches and school districts to monitor themselves and their success, we set up a process within the State of exemplary program clearinghouses with an 800 number, so that school districts and campuses that had successful ways of implementing the instructional program, whether it was in reading or in mathematics or in technology or in vocational education, could write that up, submit it to us, we would review it, we would look at it, and then we would include it as part of that clearinghouse, so that districts throughout the State could call in and find out who is doing something in this area.

One of the criticisms that we kept getting was, oh, sure, all of these good things are happening in such-and-such a district that is a suburban wealth school district, and they have all of this money. And this simply was not true. What we are able to do and have been able to do with our clearinghouse is to point out, here is a school district that has a very low tax base, high number of minority students, a very bad past record, and these are the changes that they have been able to make. And this is a school district that is very much like yours. So that we could match similar districts with similar problems and districts could learn from one another.

Also at the local level, we began looking at the creative uses of technology, the distance learning programs, to look and to offer programs in mathematics and science and foreign language in those very small isolated school districts that simply could not recruit and even did not have work for one teacher who could teach five units of a foreign language or five units of advanced mathematics. There weren't enough students in that school. So we looked at several projects, and we have mentioned them in the written testimony to see how school districts could avail themselves of, and what we have found is that the programs have been very successful.

Right now we are offering over 25 advanced level courses via distance learning, and the results that we are getting is that at minimal level, the students are doing at least as well, at least as well as they are doing under traditional circumstances with a traditional teacher. Moreover, what we are finding with some of our interactive video is that those students that we would have labeled as at risk students are doing even better through the use of the technology and the interactive video disk.

So looking at the top down, the legislative, state board rules, the setting in place, the priorities of our curriculum and then allowing for the creative local effort to implement that curriculum, our third prong then, was the long range plan for putting into place the kindergarten through grade 12 curriculum, looking at graduation requirements for the future, setting in place an assessment program that began with minimal competencies, and now having looked at the minimum competencies for four years, we are at the point where we can look beyond minimal competencies and look at maximum competencies, how would we set in place a testing program that will look at higher level thinking skills, problem solving, interdisciplinary approaches to problem solving and looking at a continuum of staff development and textbook development for the long range.

Now Texas is one of the States that, as Dr. Newman mentioned, we are a textbook adoption state. Our textbook adoption is on a six-year cycle. Once the curriculum was in place and once we had to find what were the priorities in instruction, then we began looking at beyond content, we want our instruction to include process, the problem-solving skills that Dr. Newman mentioned. We have done a very, very intensive analysis of our own test result to see how we were doing in our higher order thinking skills and moving our textbook proclamations to go beyond, to call for going beyond content and making sure that they included problem solving, strategies for dealing with different kinds of students, alternative ways of presenting the information and eliciting from students the responses that deal with particular lessons.

And most important and attached to that is the long- range plan for staff development. If there is one thing that we realize is a critical ingredient in anything that has to do with massive school reform, it is teacher, teacher, and then teacher and then more teacher. Our efforts at changing our textbooks, prioritizing our curriculum, defining what the curriculum should be, those efforts cannot gain a measure of success unless we can assure that every single teacher is trained and thoroughly knowledgeable about that content, and that is a formidable task.

So we have looked at using our seed money, our Federal seed money to develop teacher training strategies, long- range plans for cycling teachers in accordance with our textbook process, so that before the textbook is in the hands of the teachers, the teachers are thoroughly trained in the philosophy of that content area and that textbook to know how to implement this at every grade level, and our major effort now will be in the area of teacher-staff development.

Dr. Newman had talked about how—in response to one of the questions—how do we separate out in teacher-staff development whether the teachers know the content or whether it is a matter of strategies? And we have found in Texas that it is a matter of both. In some cases that we have analyzed our own test results, we have realized that there were big gaps in certain content areas. When we have gone back and worked with teachers in large numbers to see, is this just a matter of teaching teachers different, exciting, innovative ways of teaching? For example, the multiplication of fractions, third grade level. Or is this a much more fundamental problem?

In many cases, we have found that it is a much more fundamental problem and that some teachers, elementary teachers, for example, were just not given a very good background in mathematics and science when they were certified at the elementary level and, therefore, for them, it was a matter of complete training in a new content area and then moving into alternative strategies with them. Are our problems increasing or have we found some of the solutions through our three-pronged approach?

Our curriculum now has been in place for four years. In 1988, we graduate the first high school class that in high school had gone through grades 9 through 12 under the new essential elements. We have gone back and we looked at some of the results. On a statewide basis, as we look at our TEAMS' result, which is our minimal competency test, we have seen every year a steady increase in the number of students who are passing or mastering all of the tests. Particularly with our minority students, we have noticed a much greater increase every year. So we are very pleased with that.

At our high school level, we have compared our students, those students that took the SAT and the ACT results with the national scores, and what we have found is that while, as a State, if you take all of our students who have taken those tests and compared them with the national scores, our students are not doing—Texas students are still down at the bottom. But if we pull out those of our students who have taken 20, 19, 18 or 17 or more academic courses, four academic courses, then we find that our students are highly competitive. That gives us a great deal of hope, because what we feel there is that the quality of the essential elements and the upgrading of those essential elements, is paying off, that if the students will take those courses, now we are seeing a payoff in terms of any kind of national competition.

Therefore, our task now is to see how we can dip down and pull the students up from the elementary level, so that we will have more and more of those students that will be enrolling on grade level and above grade level courses.

In terms of our higher level skills, I don't think that we ever would have thought—had we not gone through this reform movement—we never would have thought of going beyond content and looking at problem solving and analysis and synthesis and seeing how we could measure that with our students. That would not have occurred to us, but given the fact that we were watching our students very carefully year after year, we now can go back and we can see where there are areas in the curriculum that need to be upgraded and also areas in teacher education that need to be upgraded.

Our schools, our students are showing that in comparison to 1983, 1982, more of our students are taking calculus, trigonometry, chemistry, advanced science courses, and this is something that we had not seen prior to the reform.

So as far as that is concerned, we feel that we have taken four years of basic reprioritizing in the State. We have looked at top down mandates, we have looked at the creativity that exists at the local level and found ways of disseminating information about that, and with that, as far as our long-range plan is concerned, we see the upward swing in our achievement results. We think that we are beginning to see a change in our system.

And with that, I will close my testimony, and I will be happy to answer your questions.

[The prepared statement of Dr. Victoria Bergin follows:]

TESTIMONY TO THE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

Representative Robert A. Roe, Chair

by

Dr. Victoria Bergin
Deputy Commissioner for Curriculum
and Program Development

TEXAS EDUCATION AGENCY

MAY 23, 1989

INTRODUCTION

Texas, like many other states, has undergone significant change in its educational system over the past decade. We have seen not one, but two, educational reform movements during the 80's. Each reform has been a response to a perceived crisis. The first reform, which was concerned primarily with curriculum, was a response by the legislature to public concern with a fragmented, inadequate, curriculum that had very low expectations of students. The second reform was a response by the legislature to a general lack of emphasis on academics. There are two ways to deal with crisis: react to it andor plan for it. Texas has done both in its three major approaches to the crisis in education. Those approaches have been to develop legislation, to encourage local initiative, and to become involved in a variety of long-range planning efforts.

It has been said that there is a Chinese symbol for the concept of crisis which is made up of the symbols for two other words. Those two other words are danger and opportunity. With every crisis there is danger and opportunity. Texas in the late 1970's faced a crisis in education. This crisis was characterized by:

- low performance on state tests of basic skills,
- low performance on SAT and ACT tests,
- a fragmented and unchallenging curriculum, especially at the high school level,
- an inadequate and unbalanced elementary curriculum,
- low graduation requirements, especially in mathematics, science, and technology.

LEGISLATION

Sparked by this increasing awareness of poor performance in public schools nationwide, the people of Texas had long voiced their dissatisfaction about the status of education, particularly the curriculum, in their state. In response to public demand, the 66th Legislature passed House Concurrent Resolution 90in 1981 resolving to study the composition of a well-balanced, basic curriculum and to recommend appropriate legislation to the 67th Legislature for implementing school reform. Public hearings called for a well-balanced, rigorous state curriculum with high expectations for students.

The findings and recommendations from the public hearings, culminated in a plan that revised, delineated, and prioritized the Texas public school curriculum. When it next convened, the 67th Texas Legislature mandated this plan, which was enacted as House Bill 246 and is often called the "curriculum reform" bill. This bill repealed all former laws relating to curriculum required to be taught and established a state basic curriculum consisting of essential curriculum elements for every course area at every grade level. In addition to the establishment of a statewide curriculum, HB 246 affected five other major areas of the education system.

1) Increase in graduation requirements. Prior to HB 246, students were required to complete only 18 units to graduate. As a result of HB 246, students in the "regular" high school program now need 21 units to graduate. Additional units were added in English, mathematics, and science. Students who wish to participate in the advanced program or the advanced program with honors must now take two levels of a foreign language, a fine arts course, and a computing course in addition to the "regular" high school program.

2) Incorporation of the essential curriculum elements into textbooks. All textbooks in Texas are purchased by the state on a six-year cycle. In 1985, the essential elements became the foundation for the textbooks, and by 1991 all textbooks adopted by the state will be based upon the essential elements.

3) Coordination of all testing programs. All statewide testing programs and all district-developed assessment instruments were coordinated with the essential elements of the new curriculum to ensure that students were tested over material included in the essential elements.

4) Teacher preparation programs. Teacher preparation programs also were required to include the content of the statewide curriculum. In addition, a portion of the teacher preparation testing program was based upon the essential elements of the curriculum the pre-service teacher will teach.

5) Development of curriculum materials. All curriculum materials, frameworks, and guides, whether developed at the state or local levels, must be correlated with the essential elements of the statewide curriculum.

ENCOURAGING LOCAL INITIATIVES

While much of the educational reform during this decade has been generated through legislation, state level policy makers see the need to encourage local initiative and innovation. This is especially true in Texas where there are 1063 independent school districts (the word 'independent' is part of each district's official name). Seventy percent of these districts have fewer than 1500 students K - 12 and are often located in isolated, rural areas. Those local initiatives and innovations that work at Houston Independent School District with 192,000 students will not necessarily work in North Zulch Independent School District with 201 students. Local districts need the flexibility to try innovative approaches to such problems as students at-risk of dropping out of school. We at the state level then try to disseminate information about successful programs through such avenues as conferences, publications, a 1-800 telephone number and on-line databases. Examples of such local or regional initiatives include:

Texas Dropout Information Clearinghouse

In 1987, the 70th Texas Legislature enacted the first comprehensive dropout prevention and recovery legislation for Texas public schools. Recognizing the need for a local approach to this population of students, the legislation required each school district to appoint an at-risk coordinator to direct the district's program and it required the state to develop a statewide clearinghouse to collect and disseminate information about dropouts and successful programs concerned with dropouts (local approaches are discussed below). The Dropout Clearinghouse publishes a quarterly newsletter, co-sponsors and provides presentations and conferences, publishes a series of practitioner guides, maintains a computerized database on dropout programs, research, and strategies, and maintains an interactive electronic mail and bulletin board service to provide timely information and announcements of programs, conferences, and funding opportunities. In addition to developing programs appropriate to their own populations, local districts are actively accessing the clearinghouse.

Local Initiatives for At-risk Students

Many local school districts have assumed the initiative in addressing the needs of their at-risk student population. Because these student needs are so varied, districts are offering a wide variety of programs. These initiatives include programs designed for intensive remediation in basic skills development for students who are academically at-risk, daycare and parenting programs for teen parents, and peer tutoring programs. Cooperative arrangements with businesses and other community organizations provide additional support for addressing the needs of this population.

Applied Mathematics, Science, and Technology Courses

Texas is currently implementing its Master Plan for Vocational Education. One of the major thrusts of the Master Plan is to ensure that vocational education courses address the changing technologies in business and industry. All vocational education courses have been reviewed and revised to more accurately reflect the new and emerging technologies. This was accomplished through significant local initiative on the part of local and state advisory committees throughout the state. In addition to revising vocational education courses, several new courses have been developed. A new course entitled the Principles of Technology (an applied physics course) has been pilot tested in two Texas school districts, and we anticipate that this course will be available to all districts in the 1989-90 school year. In this course, students apply the concepts of force, work, rate, resistance, energy, and power in a laboratory setting. Local districts throughout the state are free to develop and request approval for experimental courses such as Principles of Technology.

Texas Learning Technology Group (TLTG)

TLTG, an adjunct to the Texas Association of School Boards, was created as a partnership of the National Science Center Foundation and 12 Texas school districts. TLTG's first project was to develop, implement and evaluate a complete 9th grade physical science course delivered through an interactive video disc system.

Preliminary results from the evaluation effort show that learning is enhanced, particularly for students having low verbal ability. Additional evaluation efforts funded by the Texas Education Agency will look specifically at the use of this system with at-risk students.

Magnet Schools

There are a number of schools which have science-related magnet schools, including Houston, Dallas, and Austin. Emphasis is placed on problem solving and higher level thinking skills. Such schools include a focus on the health professions, environment, science, ecology, engineering, and others.

LONG-RANGE PLANNING

There are two general ways to deal with a rapidly changing environment: react to it and/or plan for it. At the state level, we must necessarily do both. Until the reforms, however, the Texas Education Agency had relied almost exclusively on the reaction approach. The agency reacted to the legislature, and it reacted to Select Committees that were appointed by various Governors. Beginning this decade, the agency has begun a concerted effort to plan effectively at the state level, and to encourage local school districts to plan. In addition to the legislated mandate for a long-range plan for Texas public education from the State Board of Education which is updated every four years, the agency and the State Board have entered into significant planning efforts in the areas of staff development, textbooks, and technology.

STAFF DEVELOPMENT

Mathematics Modules

Texas has utilized its state-level discretionary funds allocated through the Education for Economic Security Act (EESA) Title II to develop a comprehensive staff development program, targeted toward the Texas curriculum and focusing on problem solving, applications in real-world situations, conceptual teaching, and the use of concrete materials. By the fall of 1989 there will be 24 modules ranging from 12 to 18 clock hours for specific grades and specific mathematical content areas. Trainers from across the state are delivering the modules locally, often with the help of local EESA funds. Teachers are being provided with the type of teacher training that would be desirable for all teachers of mathematics as we increase expectations for the kind of mathematics that is being taught.

EESA Title II Staff Development in Science

Since science is an ongoing activity with new knowledge and scientific advancements, including the application of technology, there is a need for providing science teachers with quality inservice programs that apply subject matter, methodology, and instructional strategies based on current research. Science programs developed under EESA Title II have been used to develop and implement extensive statewide science inservice programs in elementary science, life science and earth science at the middle schools and physical science and laboratory safety and chemical waste disposal at the secondary schools. Funding will be provided for the development and dissemination of science materials and for training facilitators throughout the state on instructional strategies for using the materials.

Computer Literacy
When House Bill 246 was passed, there was no formal training program, certification, or endorsement that was appropriate for training teachers who would teach computer literacy. Staff at the Texas Education Agency developed a week-long workshop to train and provide materials to trainers who would in turn prepare teachers to teach computer literacy. Approximately 225 trainers successfully completed the agency workshop, and they trained over 8000 teachers in Texas on how to teach computer literacy.

District/campus Planning for Technology and Keyboarding for Elementary Students
The State Board of Education in its long-range planning adopted a state master plan for vocational education. One of the components of the plan requires all districts to teach keyboarding and other elementary computing competencies in grades 1 - 6. This effort is to be phased in between 1988 and 1992. As a first step in the process, the agency has required all districts to develop district and campus plans for technology during the 1988-89 school year. To assist districts in this effort, the agency developed one-day training modules for planning and for teaching keyboarding to elementary students and trained approximately 200 trainers around the state with the materials. We anticipate that by the end of the summer, at least one administrator from every school district in Texas will have received training in planning for technology, and at least one teacher from every school district will have received training in keyboarding for elementary students.

TEXTBOOKS

A crucial part of the curriculum reform was incorporating the essential curriculum elements into the textbooks that are adopted in Texas on a statewide basis and revising the essential elements in conjunction with the textbook adoption process. Over the past few years, the legislature and the State Board of Education have made major and innovative strides by including the use of technology in textbooks, especially those related to mathematics, science, and technology. During the 70th session of the state legislature in 1987, definitions of textbooks were changed to include "...computer software, including but not limited to applications using computer assisted instruction, interactive videodisc, other computer courseware, and magnetic media provided that these can be delivered in lieu of textbooks with similar costs to the state."

Mathematics Textbooks
New mathematics textbooks being adopted in 1990 and 1991 are required to incorporate the use of technology, specifically calculators and computers, as problem solving tools. Additionally, the textbooks will echo new curriculum directions in problem solving, higher-order thinking skills, relevant applications, and conceptual

teaching toward understanding. The new textbooks should take a dramatic step toward implementation of the National Council of Teachers of Mathematics' Evaluation Standards for School Mathematics.

Science Textbooks
New elementary science textbooks being adopted in 1990-91 also include the use of technology. The textbook proclamation for this adoption specified for elementary science textbooks and electronic instructional media systems, Grades 1-6:

"...The State Textbook Committee may list a maximum of eight textbooks for each grade (Grades 1-6). The Commitee may, in addition to the list of textbooks, list a maximum of eight electronic instructional media systems for each grade (Grade 1-6) in order to provide school districts that prefer to implement interactive instructional programs via such technology as computer courseware, videodiscs, CD-Rom, or other electronic media with an alternative to the traditional textbook. The electronic instructional media systems shall be designed as a complete program for each grade that may be used in lieu of the traditional textbook."

THE LONG-RANGE PLAN FOR TECHNOLOGY

After 18 months of work, the State Board of Education adopted in November of 1988 a Long-range Plan for Technology 1988-2000. Assisting the board in developing its plan was an advisory committee consisting of representatives from all levels of public education, technology-related private and public businesses, other industries, and institutions of higher education. Experts, including former Secretary of Labor Ray Marshall, Grant Dove, the chairman of MCC, and consultants from other states also helped. The plan is based on a substantial amount of data that establish the crucial need in Texas for a workforce able to compete in a technology-driven economy and that demonstrate the extent to which technology can improve the quality of the education system.

The plan is divided into four major sections: 1) the needs for a long-range plan for technology, 2) how technology can help meet the needs, 3) an action plan and expected outcomes for the plan, and 4) requests to the current legislature.

The Needs: A number of needs make the implementation of this long-range plan for educational uses of technology imperative. In addition to the realization of the board's vision of education, these needs include: 1) the demands of the state's economy; 2) legislative mandates; and 3) the *Long-Range Plan of the State Board of Education for Texas Public School Education, 1986-1990.*

The Successes of Technology: Although no single solution can meet all of these needs, technology has been shown to contribute significantly to meeting them. Research has shown that the use of technology can have a positive impact on student achievement, especially in basic skills, with at-risk students, and with special education students. In addition, technologies such as distance learning and telecommunication can increase efficiency at all levels of the system. For example, research has shown that: 1) Instructional television can increase student achievement; 2) Computer-assisted instruction (CAI) can improve basic skills acquisition by approximately 10 percentile points; 3) CAI has contributed to a rise in higher-order thinking skills of at-risk students of up to 25 percentile points; 4) Adaptive/assistive devices can increase attention span, retention, and problem-solving skills of special education students; 5) Distance learning is a proven means for providing effective instruction and inservice; and 6) A fully implemented statewide telecommunications system can save a projected $2 million annually in Texas.

The Applications of Technology: With the application of current and emerging technologies to education, students can work at their own pace, following the learning style most appropriate to their needs and skills and accessing libraries of information bases. Teachers' workstations can be multimedia productivity centers from which teachers can present visual and sound demonstrations, monitor individual student progress, and conduct formerly tedious paperwork automatically. Administrators can review and aggregate data on achievement, teacher assessments, expenditures, and inventories and communicate rapidly with other education institutions. Entire communities can be served by campus learning centers where adults can improve literacy and job skills.

The Actions: The calendar for implementing the plan is divided into three phases of four years each. Key actions by the state during Phase 1 (1988-89 through 1991-92) include: 1) Establish a technology allotment fund of $50/ADA/year on an equalized basis for district hardware and related purchases; 2) Reinstate support for instructional television; 3) Appropriate $16.65 million to implement the plan; 4) Establish a statewide electronic information transfer system; 5) Establish a research and development consortium and demonstration programs; 6) Expand distance learning by building on available services; 7) Authorize expenditures for technological systems through the Foundation School Program and other legislative changes; 8) Assist districts with selecting and acquiring equipment by revising arrangements with the State Purchasing and General Services Commission; 9) Incorporate courseware adoption into the textbook adoption process; 10) Revise curriculum rules; 11) Support teacher and administrator training in and by technology; 12) Through a State Board of Education Advisory Committee on Technology Standards, establish quality, technical, functional, security, service and other standards for equipment, courseware, and training; and 13) Establish Equipment Targets for districts and campuses.

Key actions by regional education service centers include: 1) Establish Technology Preview Centers; 2) Provide core services to include training and other assistance to districts in technology selection and use; and 3) Employ at least 1 full-time equivalent at each regional education service center to perform these functions.

Key actions by districts during Phase 1 include: 1) Prepare annual district and campus plans for technology; 2) Provide training to staff, including induction year teachers, in appropriate uses of technology; 3) Provide incentives for staff to use technology; 4)

Procure and integrate hardware and software according to local plans and State Board of Education Equipment Targets; 5) Use integrated telecommunications systems for instruction, inservice, and information sharing; and 6) Participate in demonstration programs.

Institutions of higher education are called on to incorporate technology in undergraduate and graduate instruction and training and to conduct and disseminate research in educational uses of technology. The consortium will, during Phase 1, initiate research projects for value-added development and marketing by member companies of educational applications of technology.

The major initiatives called for in Phase 1 of the plan have been incorporated into legislation that awaits the Governor's signature. Included with the legislation is significant funding to begin to carry out the initiatives of the plan.

NATIONAL OUTREACH EFFORTS AND THE INVOLVEMENT OF TEXAS

Texas and Psi-Net

In 1986, the Council of State Science Supervisors (CS^3) received a grant from the National Science Foundation and assistance from computing companies to establish a national communication networking project. The purpose of this project was to provide a national network system to share information from a data base. Such information includes curriculum frameworks and guides, review of current scientific theories, description of exemplary science programs, teacher shortages nationwide, and surveys. In addition, PSI-Net provides a bulletin board for member communication. During the next two years, expansion plans would encompass all interested intrastate science and math organizations, education service centers, Academy of Science, museums, and local school districts.

Project 2061

Project 2061, started in 1985, has a three-phase plan of action that will contribute to the critically needed reform of education in science, mathematics, and technology. Phase I (1985-1988) focused on the substance of scientific literacy. The outcome was a report labeled, "Science for All Americans." Phase II (1989-1992) involves transforming the conceptual base for educational reform established by Phase I into several alternative curriculum models developed by teams of educators and scientists from sites in Wisconsin, Pennsylvania, Georgia, California (2 sites) and Texas (San Antonio). Phase III (1992-2002) involves the use of the resources of Phase I and II to move the nation to scientific literacy.

Distance Learning Efforts in Texas

Texas has been a leader in the nation in offering courses for credit for students via distance learning and in providing high quality staff development in the same way. There are four major efforts in distance learning in Texas: the Satellite Educational Resources Consortium funded through the federal Star Schools legislation; the Regional Instructional Television Consortium, an Instructional Television Fixed

Service (ITFS) system in the Dallas area; InterAct, a microwave system based at the Regional Education Service Center in Houston; and TI-IN, a private, for profit satellite based system operating out of the Regional Education Service Center in San Antonio and also a recipient of Star Schools funding. As of the Spring semester of 1989, 347 districts in Texas are receiving inservice and one or more courses for credit. A total of 25 courses are being offered to these districts, with eight of them being in the mathematics, science, or technology areas. Two thousand eight hundred and eighty students are enrolled in these courses, with 383 students enrolled in the mathematics, science, and technology courses. All these numbers will grow in the future as additional Star Schools sites are added. In addition, the state's Long-range Plan for Technology and its resulting legislation, call for the state to fund additional downlinks in Texas.

* *

POSITIVE TRENDS

It is extremely difficult to show significant positive change in education in a short period of time. While it has been seven years since the curriculum reform bill passed the Texas legislature, it was only last year - 1988 - that students graduated under the higher graduation standards. It will not be until the class of 1997 graduates that we will have students who started and finished their 12 - 13 year educational career under the reforms mandated by HB 246. Nonetheless, in Texas, we are beginning to reap the rewards. While there are numerous ways to measure success, the focus here will be on the most quantitative - test results.

Statewide Testing Program (TEAMS)

The statewide testing program, TEAMS, provides that students must be tested in mathematics, reading, and writing in grades 3, 5, 7, and 9. Students who do not pass one or more parts of TEAMS are considered in need of remediation. The first TEAMS test that was coordinated with the essential elements of the statewide curriculum was given in 1986. Since then, as the chart below shows, there has been significant improvement at all levels. This improvement is even more significant because the standards for passing TEAMS were raised in 1988.

TEAMS Results
Percent of Students Passing All Tests Taken

	1986	1987	1988	1989
Grade 3	52%	63%	69%	72%
Grade 3 Spanish	-	72%	78%	78%
Grade 5	57%	60%	72%	74%
Grade 7	57%	65%	73%	72%
Grade 9	55%	58%	58%	62%

SAT/ACT Scores

We also have found in Texas that student enrollment in higher-level mathematics and science courses has increased while enrollment in basic level courses has decreased. In addition, while Texas' SAT and ACT scores continue to be lower than national average scores, the differences decrease when the scores are compared among groups of comparably prepared students. For example, the mean SAT verbal score in 1988 for Texas high school seniors with 20 or more academic units was 479, while the national average for the same group was 478. The mean SAT mathematics scores for the same groups showed Texas with a score of 531, one point higher than the national average of 530. However, only 55 percent of Texas students taking the SAT in 1988 had taken four or more years of mathematics, compared to 64 percent nationally. Only 24 percent of Texas SAT takers took four or more years of science compared to 38 percent of the national testing sample. And 47 percent of U. S. students taking the SAT had taken three or more years of foreign language courses, versus only 18 percent of Texas SAT takers. Those courses are among those that are positively related to higher test scores.

Advanced Placement Tests

Another indicator of positive trends is the number of students taking the College Board's Advanced Placement Testing Program. In 1983, 4,380 students took 5,788 advanced placement tests. In 1988, 10,478 students took 15,567 advanced placement examinations, an increase of 169 percent in the number of examinations given, and a 139 percent increase in the number of students taking such examinations. Nationally, there has been a 101 percent increase in the number of advanced placement examinations given and an 85 percent increase in the number of students taking such tests.

RECOMMENDATIONS

It is foolish to testify in front of such an august and important body without offering recommendations. Following are four recommendations for action from the federal level to further encourage better education in mathematics, science, and technology:

1) Provide training initiatives for classroom teachers of mathematics, science and technology related courses. As noted below, teachers are the key to education. The federal government could lead and assist in providing loans for teachers of these subjects to further their education. Congress could sponsor national symposia and regional meetings featuring national experts in mathematics, science, and technology and in education.

2) Continue and expand funding for Star Schools. This program is providing valuable resources and access to courses and inservice to students and teachers who normally would not receive these. Important higher level mathematics, science and foreign language courses and inservice are being developed by the various partners which received funding the first year, and these services are being beamed to hundreds of sites--primarily poor, rural, isolated schools--throughout the

country. However, there are thousands of other schools still in need of these courses. We envision a time in the next decade when every school district in Texas will have access to a live one-way video, two-way audio system. One further recommendation related to Star Schools and distance learning in general is that the federal government should take the lead in encouraging certain standards in distance learning. These standards should cover a broad array of issues from technical standards for satellite dishes to common certification standards among distance learning providers and receivers.

3) Continue and expand funding for the Dwight David Eisenhower Act. The implementation of this act in Texas is beginning to show powerful results, especially in the area of teacher training. Because teachers are among the most crucial components of a successful education system, we at all levels of education must do everything possible to recruit, maintain, and update all teachers, especially teachers of mathematics and science.

4) A final recommendation, again related to teachers, could be the most radical yet the most effective. Congress could establish "quotas" of qualified mathematics, science and technology-related teachers for each state based upon data regarding population, teacher shortages, number of minorities, and other factors. Congress could provide seed money and/or incentive money for states which reach their quota. Additional monies could be set aside for states which maintain the appropriate number of qualified teachers in these areas.

The CHAIRMAN. Thank you very much, Dr. Bergin.
The Chair recognizes Dr. Murphy.

STATEMENT OF DR. JOHN J. MURPHY, NEW YORK ASSISTANT COMMISSIONER OF EDUCATION FOR ELEMENTARY AND SECONDARY PLANNING TESTING AND TECHNOLOGY SERVICES, ALBANY, NEW YORK.

Dr. MURPHY. Thank you very much. Mr. Chairman, members of the committee. I want to thank you for giving me an opportunity to share with you some thoughts about what we are doing in New York and maybe to offer some suggestions about how you can help us.

You have my written testimony, so I will just highlight—

The CHAIRMAN. Your testimony will appear in full in the record.

Dr. MURPHY. I will just highlight the major facets of what we are trying to accomplish. New York is a State that develops State-wide curricula. We also are a State that has a statewide testing program. And these are two very important elements of our attempt to improve instruction in New York State.

We have just completed a complete revision of the entire State course of study, grades K-12, in all subject areas.

In mathematics and science, we have new State courses of study that stress problem solving, decisionmaking, try to give the kids hands-on, concrete experiences, relate science to their everyday lives and we encourage the use of technology.

In effect, what we do is say for science K-12 and for mathematics K-12, here is a State course of study that lays out what we believe the outcomes of 12 years of study in New York State ought to be for math and science. Once we have the syllabi or the curricula developed, we then develop a set of State tests. The State tests, I have to stress, come from the curriculum, so that if they drive instruction, they are doing exactly what we want them to do.

We have developed and administer a fourth grade program evaluation test, and by the way, we try to get at science content, science attitudes and science processes. We want kids as early as possible to begin to understand how scientists think and how they go about doing their business.

In our fourth grade program evaluation test, which every fourth grader must take in science, there are actual manipulative experiences, where the youngsters have to measure, they have to weigh, they have to classify, they have to make inferences, and they have to draw conclusions from a limited amount of information. The stations are actually set up in the room, because we want the testing to be as authentic as possible. We believe, by the way, that in relating math and science to real-life experiences and to making the experience concrete, it has the desirable effect of encouraging more minorities and females to participate in our science programs.

We also have a competency test in science, which is a requirement for graduation, generally taken by most students at the end of the ninth grade. We also have a 100-year tradition of the New York State's Regents Examinations, which generally are taken by the upper half of the student body in terms of performance. And we have Regents' Examinations in earth science, biology, chemistry and physics.

A similar kind of State testing program with regard to math. Our math tests in grades 3 and 6, which every youngster must take are based on the K-3 syllabus and the 4-6 syllabus. We have a math competency test which is a requirement for graduation, and we also have a revised high school course of study in mathematics, which has three Regents' Exams. We call them Course 1, Course 2 and Course 3.

I should say that we were a State which abandoned the teaching of high school mathematics pretty much the way every other State does it. In the middle seventies, folks in our math bureau realized that we were the—the United States is the only Western industrialized country, including Japan, which takes mathematics at the high school level and fragments it, and says you are going to have one year of algebra, a year of geometry and a year of trigonometry.

We created a high school course of study which we call integrated mathematics, in which the youngsters are given algebra and geometry as they need, and by the way, a question which came up earlier, it is keyed, the math sequence is keyed very closely to the science sequence, so that if a youngster takes course one in earth science, he is getting the math in course one that he needs to do earth science problem. Then in course two, he is getting a little higher math, and he is working in biology. Course 3, he or she is in much higher math and now into probably chemistry, and then physics.

It took over ten years, well over ten years for us to transition from traditional math to the integrated math. It meant, for example, phasing out all the old programs, all the old tests, phasing in the new, and more importantly, conducting intensive training programs for all the math teachers in New York State.

That, by the way, is a point I want to leave with you, and Dr. Bergin stressed it as well. I like—sometimes facetiously say, one of the things we have hit upon to improve science achievement in New York State is, we are going to teach it. I think what we find, by and large, science is ignored at the elementary level. In New York State, up until recently, in order to get certified as a common branch teacher, meaning you can teach grades K-6, any grade, all subjects, you didn't even have to take college math or college science. We found that we ended up with a lot of people at the elementary level teaching elementary school who didn't like science or didn't like the way it was taught and, therefore, they didn't teach it. I must say that having a fourth grade program evaluation test has a salutary effect on getting people to teach, because we have another requirement that there be public disclosure.

Once every year, every school board in New York State must present to the public the results of all State testing programs. We want the parents, we want the business community, we want others in New York State to have an idea about what is going on in the schools, because we need their support to bring about change.

Let me go back to the teacher training point. We have what I consider to be as good a K-6 science program as you will find anywhere. It is a magnificent document. The problem is, we have

90,000 common branch teachers in New York State. The first problem is just letting them all know it is there. I mean, forget that they pick it up and read it. But just having all of them know that a new course of study exists.

By the way, that is one of my responsibilities, and we we have a database at the State education department which has the name and address of all 192,000 teachers in it. And out of a sense of frustration, trying to figure out how do we get these documents to the teachers, we now mail them, individually, to every teacher in the State, and still I travel around the State and people say, when is the new science syllabus coming out? It's been out for three years.

You know a lot people say we shouldn't, you know, be driving instruction by testing, but I have to tell you as long as you've got the test based on the course of study you want taught, it does have a good effect.

But we need to train teachers. We need to give them time to develop local programs. We also try to strike a balance in New York State, as I am sure all States do, between State mandates and local flexibility, and we never really know when we've really struck the right balance. So that we encourage school people in school buildings and school districts across the State to use our State courses of study as the frameworks for developing their own. We have a very diverse State, as does Texas. You can go down in the east side of Brooklyn, and you've got a school that has nothing but Chinese kids in it. You can go up to the north country in St. Lawrence County and find a lot of French Canadians. So it would be silly for us, sitting in Albany, New York, to think we are going to develop a set of lesson plans that are going to make sense all over New York State.

So we encourage taking the State course of study, which have the outcomes which are going to be tested, very clearly stated in them, and having the teachers work together to develop their own local programs, having the teachers then develop materials which they can use in the classroom and then giving the teachers the time in order to sit down and say how well are we doing.

That is the biggest problem, and probably in terms of impeding reform, that is probably the biggest single problem that we have in New York State is having adequate resources to actively involve teachers in the development and assessment of local programs as true professionals.

I also think that we are missing the boat with computer technology. Sometimes I worry, I think we missed it with television. I remember I was a teacher in one of the cities in New York State when educational television was the rage, and right in the middle of one of my classes, the door opened and the janitor wheeled in a 21-inch television set. That was my introduction to educational TV. No training. No sense of how does it fit into what I'm doing.

We are doing the same thing in a large extent with computers. If you have a dollar to spend on technology, you should probably spend a quarter on hardware, a quarter on software and 50 cents on planning and training. We spend about 99 cents on hardware. We're spending hundreds of millions of dollars on computers, and we are not putting any dollars into finding out how can this wonderful new machine—education is essentially an exchange of information business, and this computer can revolutionize the way we handle information and with interactive video disk, and networking machines going out to outside databases, the only restriction on the use of computers is our own creativity.

Texas—Dr. Bergin mentions something called exemplary programs. We took full advantage in New York State of what I thought was a magnificent Federal program called the National Diffusion Network, which encouraged the development of innovative programs, has with it a very rigorous validation or evaluation process, so that the consumers will know if an educational program goes through the national validation process, or we have copied it, we have a State validation process as well, they know that they are getting a good product.

The City of Buffalo in New York State, for example, just to give you an illustration, several years ago was under a court order to desegregate its schools, still are under a court order. They made up their minds that, sure, they were going to desegregate but what they were going to do was improve education for all. And so they redesigned the entire—it was a school district of about 50,000 youngsters, 72 buildings. They redesigned the entire elementary program, put in an entire new elementary program. It was entirely taken from programs that were validated across the country in the National Diffusion Network. I think it is one of the low-cost most effective change programs we have ever used in New York State.

I think programs like the National Science Foundation, the old NDEA, if we could get groups of teachers working together with experts in technology and experts in the academic world, let's figure out how we can integrate the computer and all this wonderful technology into the classroom, so that we can improve instruction.

So those are just some of the things that I wanted to highlight from my testimony. And along with Dr. Bergin, I would be happy to try and answer any questions you have.

[The prepared statement of Dr. John J. Murphy follows.]

TESTIMONY

BY

JOHN J. MURPHY
ASSISTANT COMMISSIONER
NEW YORK STATE EDUCATION DEPARTMENT

ON

SCIENCE AND MATHEMATICS EDUCATION

BEFORE
THE COMMITTEE ON SCIENCE, SPACE
AND TECHNOLOGY
WASHINGTON

May 23, 1989

Introduc

From 1979 to 1984 the New York State Board of Regents managed a process involving thousands of people in New York State which led to the creation of the New York State Regents Action Plan to Improve Elementary and Secondary Education Results. The Action Plan, as it is popularly called, contains a blueprint for educational reform in New York State. Staff in the school districts and at the State Education Department have been implementing that plan since 1984.

A key feature of the Action Plan is the complete redesign of the entire State General Education course of study in every grade and every subject, grades K through 12. A related feature of the plan is an expanded New York State testing program designed to provide information on the extent to which the goals of the plan are being achieved.

Mathematics and science education programs in grades K through 12 have been completely redesigned in New York State. The specifications for the redesign contained in the Action Plan provide a blueprint for State and local officials in the design of new programs. My testimony will focus on the changes we have been attempting to make in mathematics and science education in New York State over the past five years, and I will conclude by indicating ways in which the Federal Government can assist us in that continuing process.

Mathematics and Science Education

This section of my testimony will review mathematics and science education in New York State. The review will make reference to our new courses of study and methods of assessment, and will conclude with some recommendations specific to mathematics and science education.

Mathematics Education

New York State has introduced an innovative high school mathematics program which places it in the forefront in mathematics education nationally. Some ten years ago the traditional high school mathematics sequence consisted of Algebra in grade 9, Geometry in grade 10, and Algebra II/Trigonometry in grade 11. Following a successful pilot study, that sequence was replaced by an integrated mathematics sequence which blended previously isolated topics. The present Course I, which is now the required first year high school mathematics course for all college bound students in New York State, includes such topics as Algebra, Euclidean and Transformational Geometry, Probability, Statistics, and Logic.

In addition to an integration of mathematics topics at each year of study, there has also been an increased emphasis on problem solving. There is an effort to stress problem solving and critical thinking skills throughout each strand and each year.

The new program has resulted in a higher percentage of students taking more mathematics than was previously the case. Specifically, more students are currently completing three years of mathematics study. Studies also indicate that females are now participating in mathematics to a greater extent. At present there are approximately equal numbers of males and females completing three years of mathematics.

Recommendations in two recently-released national reports, one by the National Research Council, "Everybody Counts: A Report to the Nation on the Future of Mathematics Education" and one by the National Council of Teachers of Mathematics, "Curriculum and Evaluation Standards for School Mathematics," have stressed higher order thinking skills and the elimination of fragmented programs. New York State's mathematics syllabi for grades 9-11 compare favorably with these recommendations.

Additionally, two new middle school syllabi have been developed which compleent and support the objectives in the high school syllabi. In addition to traditional topics usually covered at the middle school level, these new syllabi also include strands on probability, statistics, algebra, and computer awareness. Problem solving also occupies a prominent position at the middle school level.

The Mathematics K-6 syllabus, although in place since 1980-81, meets most of the recommendations suggested by these two prestigious national groups as well. Problem solving is once again the focus of the program. The use of manipulative materials to illustrate mathematical concepts is encouraged at all levels.

In New York State our testing program is designed to monitor student performance periodically. Pupil Evaluation Program (PEP) tests in mathematics are given to all students in grades 3 and 6, Regents examinations are given at the end of each of the three high school integrated courses--normally at grades 9, 10, and 11 for non-accelerated students, and Regents Competency Tests (RCTs) are given to all high school students not registered in the college-bound integrated courses.

Students scoring below a specified state reference point on the elementary PEP tests or failing the high school RCT are mandated to receive remediation to assure that they meet specified minimums. Such remediation is provided by local or specially earmarked state funds and may be supplemented by federal Chapter 1 monies.

Excellence is also encouraged by the state. All schools are required to provide eighth grade acceleration in two areas, one of which must be mathematics. The goal is to give qualified students the opportunity to sit for a Calculus course as seniors following the three year sequence and a fourth year of pre-calculus. This requirement to provide qualified students with accelerated courses has been quite successful, as illustrated by the fact that New York State students take more Educational Testing Service (ETS) Advanced Placement (AP) Calculus examinations than any other state in the union.

New York State's average mathematics Scholastic Aptitude Test scores are usually near the national average, and a high percentage of our students--72 percent of our high school seniors--take the test. In addition to the many students taking AP examinations, as noted above, other indicators of excellence attest to New York State's prominence. New York State's students win a very high percentage of Westinghouse Science Talent Search awards, achieve near the top on Merit Scholarships, and have very high averages on Level I and Level II Mathematics Achievement Tests produced by ETS.

Science Education

Innovations in science education have been occurring in New York State from kindergarten through grade 12 for the past 20 or more years. Within the past five years, developments have been made which have had significant impact within the State and could have a similar impact nationally.

Elementary Science Education: In general, and specifically for science education, the most crucial point in the formal educational experience for children is in the initial grades. Without a solid foundation to build upon, any curriculum architecture will crumble. In New York State a curriculum framework, the Elementary Science Syllabus, was developed, distributed, and implemented, beginning in 1985, to provide consistent direction for instruction. Statewide program evaluation also occurs to monitor the degree of attainment of the curricular outcomes. A support system of trained resource agents, Elementary Science Mentors, has been established to provide help at all levels to staff and administration faced with the ongoing problem of providing quality elementary science education.

The Elementary Science Syllabus provides guidance on how to use hands-on experiences for children to investigate their natural world. These investigations are a focus for problem solving as children are exposed to discrepancies which stimulate them to ask questions. Good questions are the beginning point for effective problem solving. Through problem solving children are able to develop their skills (inquiry and language arts), positive science attitudes, and scientific knowledge. Syllabus supplements have been developed to provide examples of student activities which the schools may choose to use in their locally developed elementary science programs.

The Elementary Science Program Evaluation Test is a State assessment effort administered at grade 4. It consists of seven components, two mandated and five optional. This instrument provides local educators and the State Education Department with data on the degree of attainment of the desirable learning outcomes through grade 4 and will provide a measure of the "health" of the local instructional environment. The two mandated components include a 45-question criterion-referenced test of content and skills and a manipulative skills test that consists of five stations of exercises. These exercises evaluate a number of inquiry and communications skills through student hands-on experiences that cannot be evaluated by conventional paper and pencil techniques. The five optional components include a student attitude survey and four science program environment surveys for students, teachers, administrators, and parents. By analyzing the items on these instruments and comparing results to State and local standards, local educators will be able to make better decisions about the quality of their local elementary science programs.

The Elementary Science Mentors comprise a Statewide network of about 100 regional resource agents who have been trained to provide technical assistance to school districts in areas of program development, instruction, communication, and testing. These resource agents represent both the public and nonpublic school sectors and assist educators in the State's 4,000 elementary buildings.

Training provided to the regional Elementary Science Mentors has enabled them effectively to assist local elementary educators to implement the State syllabus, develop local programs, and administer and analyze the program evaluation tests.

While State funds have been used to create the syllabus and the program evaluation test, funds needed to create and support this vital technical assistance network have come almost exclusively from EESA Title II.

Middle/Junior High School: Middle school/junior high school efforts in the State build upon the foundation begun in elementary school.

A major innovation completed in 1985 is the tenth "block" or module in the series of State syllabi for grades 7-9, called Science, Technology and Society, Block J. This publication was one of the first efforts in the nation at this grade level to isolate the essential learner outcomes of the interaction among science, technology, and society (S/T/S). Forty-nine understandings are specified, and sample activities are provided that teachers can use with their students. Because of the design of the publication, teachers do not teach S/T/S in isolation, but are able to apply the understandings to the other nine syllabi that deal with outcomes in the life, physical, and earth sciences.

School personnel continue to become familiar with this new syllabus and the new expectations for 7-9 science, namely the importance of including S/T/S within science education. Block J is causing teachers to open up their instructional programs to expose students to the applications of the science that is being taught as well as explore the social issues which result from science and technology.

The Regents Competency Test in Science (RCT): The RCT in Science was administered for the first time in New York State in June 1988. This examination sets a minimum level of competence in the natural sciences that students must demonstrate as an outcome of instruction in grades 7-9 in order to meet one of the high school graduation requirements.

The Regents Competency Test in Science is constructed of guidelines established in a core of process skills and understandings taken from the ten State syllabi, or Blocks. The core of process skills are summarized in a guide publication. As a result of the annual administration of the RCT in science, local educators can review the performance of their students to identify areas of weakness and provide corrective measures. The data can also be used to make program changes in an effort to improve or maintain the quality of instruction in science education.

Unified Science: Unified Science, Solving-Problems in Science, Technology and Society is a State-developed syllabus specifically created for grade 10 students who need a second year science course but do not want to study only one discipline of science for a full year. The principal instructional emphasis of this syllabus is to teach science as investigation and research that leads to the understanding of real life scientific/technological/societal problems that have relevance in the students' lives.

Science Education for All: Of great concern in science education, of course, is the continued under-representation of females and minorities in the ranks of scientists and engineers and the lack of scientific literacy for citizenship that these groups generally exhibit. The efforts already described in the areas of elementary science, middle-level science, and unified science in New York State address this concern.

Programs that stress "hands-on," concrete activities have been shown to be effective with both females and minorities. Likewise, programs that stress the connections between science and students' everyday lives and the society they live in decrease "science anxiety" and promote the continued participation of females and minorities in high school science courses such as the Regents sciences.

Recent data on the participation of females in the Regents sciences in New York State show nearly equal participation rates of males and females in Regents Earth Science and Regents Biology, where 51 percent of the students are females; in Regents Chemistry the participation rates of males and females are 50-50, exactly equal. The participation rates of females in Regents Physics is at 41 percent, a number we are working to increase, but even this rate is significantly higher than the female participation rate in physics for the United States as a whole.

Observations and Recommendations

1. At present there are few mathematics and science specialists in the elementary schools, and the typical elementary teacher has 6 or fewer collegiate hours of mathematics and/or science. At the secondary level some areas of the state, especially in the urban and quite rural areas, have been experiencing a mathematics and science teacher shortage and have been forced to hire uncertified personnel. Although other areas of the state have a sufficient supply of certified mathematics and science teachers at this time, many teachers are beginning to reach retirement age. These facts, along with the reality that colleges are not producing many mathematics and science teacher candidates, must be taken as a warning signal. If we are to produce competitive mathematics and science students, we must have a sufficient number of qualified staff in all the schools. Federal resources should be directed at providing pre-service and inservice training in content and pedagogy.

2. The need for continuing in-service training for practicing mathematics and science teachers is as great as the need for stronger pre-service education to prepare more and better teachers. With the recent strengthening of New York State's courses of study in mathematics and science and the realization of the need to incorporate the use of technology into classroom instruction, the role of in-service becomes crucial.

3. Although many of the national reports have stressed the importance of critical thinking and problem solving, the research base in such areas as metacognition is just beginning to be discussed. Whether or not these higher order thinking skills can be taught and if so how, will require much more study. Federal resources should be directed to assist with these studies and the dissemination of the findings to teachers in the field.

4. Although some of the experimental mathematics and science programs are beginning to use the calculator and the computer as tools in assisting with the traditional mathematics and science topics taught, there is still much discussion on the curriculum impact of the new technologies. Since the newer hand-held calculators will perform many of the symbol manipulations now required in algebra and calculus classes, for example, how should the curriculum be restructured? Federal resources should be directed at determining the effect of technologies on the mathematics and science curriculums at all levels.

Summary

The keys to success in New York State mathematics and science education center on three important components.

1. Direction in specifying learning outcomes provided through State syllabi which set minimum standards for attainment.

2. State-developed student achievement and program assessment testing instruments that monitor the degree of attainment and provide corrective measures for improvement and maintenance of quality instruction.

3. A support system of resource agents that has the capacity to deliver technical assistance to local educators who are attempting to improve or maintain the quality of their local science education programs.

Financial support to accomplish these three components requires collaborative local, State, and federal assistance. EESA Title II has been an indispensable "life blood" for New York State science education. Its continuance and expansion through DDE Title II and subsequent acts will be vital to the continued "health" of science and mathematics education in New York States's public and nonpublic schools.

Innovative Approaches

Several innovative approaches, in addition the recent initiatives in State Syllabi and assessment for mathematics and science, demonstrate the variety of ways in which New York State is in the vanguard of excellence in mathematics and science education. These innovative approaches include CIMS--Comprehensive Instructional Management System, the Model Schools Program, and Distance Learning.

CIMS

CIMS--Comprehensive Instructional Management System--is a partnership between the State of New York and local school districts designed to develop and improve local instructional programs. CIMS development was supported initially in 1973 with ESEA Title V funds. Its subsequent expansion from the original developer sites was partially funded through ESEA Title III. Neither of these Federal funding sources remains available, and since 1982 CIMS has been supported in its replication throughout New York State solely with state and local funding.

CIMS makes the curriculum the key to a successful instructional program by defining curriculum as "an ordered set of intended learning outcomes" in which teachers and administrators keep track of how effectively these outcomes are met. CIMS has four components: curriculum, assessment, instruction, and staff development. The curriculum drives the other components. There are presently over 800 schools and

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400,000 students participating in CIMS Math for grades K-7, while over 260 schools and nearly 90,000 students are involved in CIMS Science for grades K-6.

The CIMS components are developed by teachers from many school districts working together with the support of project coordinators located in regional BOCES (Boards of Cooperative Educational Services). This cooperative developmental process is the strength of CIMS.

Since the CIMS Math curriculum is based on the State Syllabus, indeed, translates the syllabus into an instructional scope and sequence, its emphases reflect the importance of problem solving, the notion that concept development ought to arise through concrete experiences, and the awareness of the need to integrate new technology, such as hand-held calculators and computers, into classroom instructional practices. Accordingly, a revision of the CIMS curriculum completed in 1986 takes the approach that problem-solving is not just one of several curricular strands but is implicit in all other strands. Recent revisions of CIMS' criterion-referenced assessment reflect the prominence and integration of problem-solving in the curriculum. Additionally, staff development provided through a turn-key mechanism to all CIMS Math teachers has helped the teachers to implement the new emphasis on problem-solving in their instruction.

In CIMS Science, the State Syllabus is again foundational. In the CIMS Science philosophy-rationale statement, the developers explain that hands-on experiences are essential as a sensory base for the eventual derivation of concepts, drawing of conclusions, and interpretation of phenomena. Without hands-on experiences, children are dependent on other people's interpretations of phenomena. Consistent with this philosophy, CIMS Science assessment includes guided study kits for teachers to use to help them observe how students process hands-on experiences. Through these assessments, teachers are enabled to evaluate students' ability to draw valid conclusions from a set of data, describe accurately a condition observed first hand, predict an outcome based on information or previous experiences, manipulate equipment effectively, and recognize proper techniques for conducting experiments.

Both students and educators benefit from participation in CIMS Mathematics and Science. The teachers and administrators benefit from the focused communication which the curriculum development and implementation process promotes and from the inspection of assessment information directly related to the curriculum. The teachers benefit in terms of more accurate placement of students in instruction, which optimizes the use of classroom instructional time. And all educators benefit from the staff development, which strengthens their instructional skills, and from the increased availability of resources to support instruction, such as science instruction kits. Students in turn benefit through the increased purposiveness of the instruction they receive and from the heightened enthusiasm for learning which is communicated by their teachers.

Model Schools

The New York State Board of Regents have recommended that technology be integrated within the curriculum and programs of the schools at all grade levels. Moreover, the Regents have encouraged the use of technology as a "tool" of instruction. The Model Schools Program, established in 1985 as an entirely State-supported effort, represents innovative applications of technology in mathematics and science in its development of extensive technology-based instructional materials. The foundation for the development of these technology-based applications has been the training which the Model Schools Program has provided to participating teachers. These teachers have been trained to incorporate technology into all subject areas to enhance the delivery of instruction. This has been critical in the facilitating the application of technology in mathematics and science instruction.

The Model Schools Program includes extensive training for students in the area of tool-software (for example, spreadsheets, data-bases, word processing, and computer graphics) which has enabled students to record, analyze, and store scientific data electronically. Science probes are used to measure temperature and light. Lesson plans in the areas of mathematics and science are available in IBM and Apple versions. Chemistry lessons have been developed in association with the Chempac lab program, providing quantitative preparation, instant data evaluation, and New York State curriculum correlation. Actual required lab work, not simulation, is conducted using carefully designed reactors.

Unique technology-enhanced instructional applications of the Comprehensive Instructional Management System (CIMS) mathematics and science curricula have been developed by Model Schools teachers. These lessons have given teachers the methodology to vary classroom presentation, elevate student motivation, and serve new student populations in Special Education.

Model Schools teachers are developing lessons in mathematics and science using interactive video technology. Life Science, Earth Science, Astronomy, Health, energy, plants, animals, and weather lessons have been highlighted via compact disks and teacher coordination. This technology affords the teacher the opportunity to introduce a unit, reinforce important scientific facts and procedures, and test for recall and comprehension. Mathematics lessons accentuating a step-by-step approach to learning algebra and geometry have inspired new enthusiasm among students.

New methodologies have been explored utilizing calculators and computers to encourage young children to investigate math facts before memorizing. Correlated software for drill and practice are additional classroom tools.

Three additional projects in science and mathematics have been developed for the Model Schools program utilizing a hypermedia system.

- Minerals. This project was developed to demonstrate how hypermedia could support specific curriculum objectives. The student utilizing the system is presented with a list of minerals, one of which has been distributed to the student. On the screen is a list of "ruled out" minerals and a series of tests which the student can perform. The system is used to record the results.

- Hypermedia System for Interactive Video and Voyager SpaceDisc. The second project uses a hypermedia system to control an interactive videodisc player and the Voyager SpaceDisc. It allows the student to investigate the Voyager results from a number of points of view: centering on the spacecraft and scientific equipment itself; either of the planets (Jupiter or Saturn) which Voyager had visited when the videodisc was mastered; or on particular scientific experiments which were performed during the Voyager mission.

- Hypermedia System for Calculations in Matrix Manipulation. The third project uses a collection of hypermedia scripts which perform the calculations involved in matrix manipulation. This allows the student readily to formulate and test hypotheses regarding relations between matrices and the operations performed on matrices. It is not an instructional package; it merely facilitates the calculations involved.

Model Schools shares mathematics and science curriculum materials and technology-enhanced pedagogy via the Statewide Technology Network Ties (TNT) System. In addition to E-mail and conferencing, management and instructional data are reviewed, collected, and disseminated.

Our experience with the Model Schools Program suggests the following benefits: Creative lessons and classroom enrichment heighten student interest and excitement, motivation to learn is increased, more hands-on opportunities are provided, and a variety of experiences not otherwise available become a reality.

Distance Learning

Distance Learning is the use of computer and telecommunications technology to expose students to the benefit of instruction delivered to them by teachers who are in different locations. New York State BOCES and school districts have implemented distance learning pilot projects during the past three years to assess their impact for providing a variety of advanced placement courses and high-quality staff development opportunities to students and teachers. The projects were implemented under a grant program, entitled the Technology Network Ties/Distance Learning Grant Program, during 1986-87 and 1987-88.

Five projects implemented under these funds were involved in the provision of instruction and staff development opportunities in mathematics and science.

- Distance Learning Project in Western New York

  ERIE I BOCES, in collaboration with Houghton College, Buffalo City Schools, and five other schools and BOCES, implemented a distance learning project using the Optel telewriter/IBM teleconferencing system to offer AP Calculus and AP Science courses to students in rural schools characterized by geographic isolation, declining financial resources, limited teaching resources, and limited enrollment.

- Computer Conferencing for High School Courses

  The Islip Union Free School District 2, in collaboration with the New York Institute of Technology, offered courses in statistics to high school students. The distance learning system employed was a computer conferencing network that used personal computers networked to a computer facility located at the New York Institute of Technology.

- Telecommunications in School Rural Schools

  The Delaware-Chenango BOCES, in collaboration with twelve school districts, used the Optel/IBM teleconferencing system to provide students in the cooperating schools with Advanced Placement courses in Calculus and Astronomy. A variety of "electronic field trips" related to mathematics and science were conducted.

- Long Distance Teaching

  The Steuben-Allegany BOCES and nine cooperating school districts used their current microwave translator system, VHF radio signals, and data communications technology to offer courses in Advanced Math, Calculus, and Advanced Physics.

- TELECOM5 Educational Network

  A staff development program on the health sciences was provided to teachers in the Southern Tier region of New York State by the Broome-Delaware-Tioga BOCES, a local PBS affiliate, and five participating BOCES. The project utilized existing broadcast facilities to deliver the staff

> development teleconference to schools in the region. The project coordinators are exploring the potential of using the current microwave tower and communications systems of the BOCES for the transmission of future staff development and instructional programs.

Benefits of Distance Learning include the provision of advance placement mathematics and science courses to students who would not otherwise have had these opportunities and increased general exposure to excellent intruction provided by highly-qualified teachers. In local schools with low potential enrollments in advanced mathematics and science courses or in low-density population regions, such as some rural areas, Distance Learning brings together students and teachers who would otherwise never have encountered one another.

Recommendations for Federal Action

There are a number of programs that the federal government has historically put in place to encourage science education throughout the United States. Some of those efforts have been specific to science or mathematics education, while others have been of a general nature where aspects of such programs have led to a strengthening of science and mathematics education. New York State recommends that the Congress consider the following.

1. The National Diffusion Network has been instrumental in transferring successful practices throughout the nation. Arranged to accommodate educational programs of all styles and types, its acceptance throughout the country has been strong. Most importantly, its no-nonsense, tough and defensible validation process has rewarded innovation and supported replication of successful practices while insisting that what passes the network's validations has substance. More of the National Diffusion Network activity should be supported in the ensuing years. The National Diffusion Network should be funded to enable it to accommodate the wide range of promising practices. Further, the National Diffusion Network process should continue to have strong funding for demonstration programs and seed money for replication in local districts. The use of the National Diffusion Network can be an extremely efficient and effective way of bringing about changes in mathematics and science education.

2. The National Science Foundation has been responsive both to the needs of the regions of the United States and to the priorities of the federal government. National Science Foundation programs have been well-conceived but underfunded. The beginnings and promises of the 1960's have lost precious ground in real dollar amounts in the ensuing years. The strength of the National Science Foundation--particularly

in those programs which will accommodate teacher training and enhance the background, the content, and the teaching methodology of America's teachers--must be funded with a renewed commitment. The National Science Foundation is often held to be accountable in a major way for federal good works in science education in the U.S. Without the corresponding funding this agency will be unable to meet any federal mandate, however vaguely articulated, related to improving American science education.

3. Because there are so many federal programs that directly impact the nation's schools from various agencies of the federal government and because within the federal government there are many promising programs developed for the Department of Defense, the War College, and the United States Service Academies, a clearinghouse is of the utmost importance. This clearinghouse should be a database that is simple to use and responsive to local queries. The database should include information about existing programs that can be used for potential replication. The clearinghouse should also include information about the federal government's activities in training and in educating its own employees where their practices have proven successful. The clearinghouse should also include information about the many federal programs that serve and have potential for funding and entrepreneurship in the schools, regions, and states that might apply for cooperative program developments.

4. The National Defense Education Act has been forgotten by most. Yet the rhetoric of the reform movement continually points up the need in science education for more laboratory experiences and hands-on techniques. This cannot happen without the encouragement of a program such as the National Defense Education Act, which provided matching funds to supplement efforts of schools to increase their holdings of science equipment and materials for student learning.

5. The focus of federal funding on educational technology is important. A great need in educational technology is to bring the very best in technology to bear on educational programs and solving educational problems. Whether it is teleconferencing by public and commercial television stations, cable networks, and other satellite type arrangements, distance learning via the computers and various transferring media, or improving networks of schools via computer lines and television--all of these technological components can profit from federal intervention in support of increased technology by way of information available from the federal government, which uses technology at its best and at its frontiers. The need for funding to support the high expense and encourage networks, thereby saving expense through efficiency, cannot be denied.

6. Supporting a strong educational research component would be a boon to those in school districts, regional centers, and the state departments of education who seek data which demonstrate the effectiveness of various models of achievement throughout the United States. A strong educational research component--a procedure for supporting research in education which would rigorously test its conclusions and direct support to promising research programs--could be of timely and important assistance to all.

7. As indicated previously, the great strides we have made in science education, especially at the elementary level, have been heavily dependent on EESA Title II funding. Specifically, funding from EESA Title II has enabled us to support our syllabus initiatives through the regional Elementary Science Mentors. The Science Mentor program is now in serious jeopardy. The shifting of the federal funding mechanism away from EESA Title II to DDE Title II, while it has created the appearance of supporting local science education efforts, has in fact reduced by more than 50 percent the State's capacity, through the Science Mentors, to provide the support for local efforts which is essential to their inception and continuation. Last year in New York State we had 100 regional Elementary Science Mentors supported through EESA Title II funding. This year, because of the shift to DDE Title II and the resulting redistribution of funds, we will have no science mentors. The excellent start we have made will have been for nothing because of our incapacity to follow up through our Science Mentors. Retaining the relative distribution of federal funds according to the EESA Title II formula is absolutely crucial to the ongoing success of elementary science education in New York State.

Thank you very much for allowing me the opportunity to provide my testimony on New York State's perspective on mathematics and science education.

The CHAIRMAN. The Chair wants to thank both of you very much.

The Chair recognizes the distinguished gentleman from New York, Mr. Boehlert.

Mr. BOEHLERT. Dr. Murphy, I hope you didn't notice that we were sniggering up here, when you told that story about the janitor wheeling the 21-inch TV into the classroom. The sad fact of the matter is that the janitor was probably making more money than you, the teacher, at that time.

Dr. MURPHY. Probably.

Mr. BOEHLERT. When you developed your new curriculum, where did you find the textbooks to go along with the new curriculum?

Dr. MURPHY. Well, we are not a textbook adoption State, and we developed what we thought was the kind of science program we needed in New York State. Our expectation is, and this is generally true, and if this sound arrogant so be it. Generally, what happens, we are a large enough State so that the publishers can't wait to get their hands on our new syllabi, and you will find textbooks coming out keyed to the New York State curriculum, even to the point where the covers of the text are the same as the covers on our syllabi and the outline in the test is exactly the same.

We also feel that—I dwelt a little bit in my testimony on the CIMS program. And that is where we have invested some money in having teachers develop their own materials. We find a lot of those teachers don't want textbooks and they don't need them. They know what it is they want to accomplish. They have assessment instruments that tell them at the beginning of the year where the youngsters are in terms of what it is they have planned for that year. They have worked together as professionals to develop instructional material, science kits, math kits that the kids can use in class. They have regular criterion reference tests they use for formative evaluation throughout the year. So they really don't need and don't want textbooks.

We will find within a couple of years after we publish new syllabi, that there will be textbooks on the market that meet our—there are, for example, several publishers that now publish integrated math textbooks, even though we are the only State, to my knowledge, and some other large cities have adopted integrated math, but we are the only State that has integrated math.

Mr. BOEHLERT. I don't know if this perception is accurate, but it has been my perception that we are seeing a lot more science fairs and math competition at the elementary, secondary level now. Now my experience is New York, upstate, and is that a conscious effort on the part of the State to encourage this type of competition, one and secondly, are you reaching out to industry to get more support for this type of competition because it costs money?

Dr. MURPHY. Yes. We work very closely with the New York State Business Council, for example. They are very much involved with us, in terms of chiding us about doing a better job than we are doing, but also supporting efforts like local science Olympiads all over the State.

Mr. BOEHLERT. Are they putting their money where their mouth is?

Dr. MURPHY. Yes. Yes.

Mr. BOEHLERT. That's refreshing.

Dr. MURPHY. Yes. And not only that, but equally important, maybe more important, is support in the Legislature. IBM and Apple Computer, for example, have participated in—I mentioned the model school programs—in the use of technology. We have been very active partners with IBM and model schools, and once you get those two in, the other vendors line up to try and get involved.

Mr. BOEHLERT. Dr. Murphy, are you working the media too? And I will tell you why. Recently in Utica, Utica College, they had a science fair type thing, and it was fiercely competitive and well-attended, and there was virtually no coverage by the local media which really bothered me. And I spoke to the publisher of the paper about it, and in the future that is going to be corrected.

Then I would also like to talk to Dr. Bergin about that same type of activity, the science fairs, the math competition on television, that type of thing.

Dr. MURPHY. Just let me comment on the media. I would be the first to admit we are not good at that, but secondly, at least I can't speak for the media outside of New York, but I can for the media in New York. They love bad news.

Mr. BOEHLERT. I know it.

Dr. MURPHY. You can have the most wonderful thing going on, as New York City is a good case in point, where a community school district, District 1, was having this magnificent Christmas Party. They were going on a boat, and they were going to go around the Island and Santa Claus was going to come in on a helicopter. I mean, it was just a marvelous experience for hundreds of kids. So he called the Daily News and he said—told them about it. And the answer he got is, we're into negative things now. They weren't interested in covering that.

But also in terms of the media, that is why the Board of Regents put in the requirement of public disclosure by building, at least once every year, three years of trend data, in fact, we do the report, most of the report, at the State level and mail it out to the buildings and to the districts, because we want more attention called to what is happening and what the problems are as well as the successes.

Mr. BOEHLERT. Dr. Bergin, how about Texas and the science fairs, the math competitions, that type of thing.

Dr. BERGIN. A lot, a lot of attention to that. And we have been very fortunate with the media coverage on that. I think we started out about three years ago with that, and now we have very, very good communication with the media. We get a lot of coverage, and as a result, and we also include the legislators in Texas in our media coverage, so then we hope that that leads to more support at the legislature for what we are talking about.

Mr. BOEHLERT. But don't you feel this excites the kids?

Dr. BERGIN. It excites the kids, and it also does something that I would say ten years ago I had never seen. Ten years ago, I walked with the Houston School District. When we had science fairs, we saw the same kinds of children, students, that were the ones that were submitting things, and they were usually always white, and they were mostly male. I think now with the attention that we have given to the new curriculum supporting competitions, whatever the competition may be and getting our business people involved in supporting that with us, you are seeing school districts that are primarily minority districts that are also getting up to the top of the competition, and now we are seeing a multi-ethnic kind of involvement in that. Very big.

Mr. BOEHLERT. Let me ask you what both States are doing in terms of reaching out to the private sector and bringing in as resource material from a General Electric or Texas Instrument to help in the classroom. Is that something that is workable that is being done? Are you having union problems with that?

Dr. BERGIN. No, we are not having any union problems with that. It is working. It is very, very successful. We are doing it with "adopt a school" programs, "communities in school" programs, our TAME program, the Texas Association for Minorities in Engineering, but I know this is a national organization, is very, very good at bringing the businessman in and also bringing not just the businessmen but peripheral organizations, whether it is the hospitals, the churches, the community groups that might be like the Chamber of Commerce, to bring those into the schools and have them work on their pet projects, and it is turning out that most of the pet projects happen to be math, science, technology oriented. Very successful.

Mr. BOEHLERT. Well, when you bring these people in from industry, these successful people from industry, they automatically serve as role models for the youngsters, and so I hope you are being very conscious of the need to have women and minorities as part of that program.

Dr. BERGIN. Absolutely.

Mr. BOEHLERT. And the other part of it is—and I wish we could keep both of you all day long, and, Mr. Chairman, I wish you could keep the floor all day long. I know I can't, so I will shut up in just a minute.

The other thing is, I am trying to encourage industry to reach out to the teachers in high school particularly and give them some opportunities to supplement their income, consulting arrangements, temporary work arrangements, that type of thing, because the fact of the matter is, teachers aren't well compensated, even in New York, Dr. Murphy. You know it as well as I do. So I would like to have them get more, and those bright young kids coming out of college, facing an offer from a General Electric for $45,000 or from my high school district, which is a new one, New Hartford, to start at $17,000, and they've got this big debt they've got to pay back to the government, they are looking to pay it off in a hurry.

So I would hope both States would encourage industry as much as possible to employe the talents of these people.

Dr. MURPHY. Just as an observation. I agree with what Dr. Bergin said. We are also getting help from another source, and that is from the armed services. We have a military education liaison committee, and I chair that, and we meet four or five times a year with representatives of all the armed services. We have a lot of mutual problems, in terms of recruiters getting access to kids, maybe being overzealous or having guidance counselors that block the recruiters, any access.

That is how we get started. But the more we talk to each other, the more we realize what we have in common. The want high school graduates. We have decided in New York State that we teach values. We now inculcate democratic American values into all of our subject matter, just like the military has an interest in values. They have been very good, in terms of taking large numbers of vocational education teachers to naval installations where they would get training firsthand in the use of the very sophisticated equipment. We are working with the Army now through General Collins on a role model program, where they are finding successful young soldiers from, say, South Bronx High School and sending them back to South Bronx Hospital to go around and talk to the youngsters as a role model program.

And we find technology transfer. We are talking about looking at all the kind of software that has been developed in the military to teach languages, to teach match, to reach remedial subjects. We are looking at ways we can transfer that into New York and get some benefit out it. Very good cooperation from the military.

Mr. BOEHLERT. Finally, could I ask both of you to comment on the bill, my bill that would provide stipends of $7500 a year for the juniors and seniors and undergraduate math, science or engineering, in return for a commitment of two years of teaching for every year of the stipend.

Is this something that you think will be helpful?

Dr. BERGIN. I think it would be wonderful. I really do. I think that's a wonderful idea. I think anything that is going to focus on getting a teacher in the classroom and that will make it attractive. If we get them for two years in the classroom, then that is fine, we've had them for two years. We've had their energy. We've had their good ideas. We've had their good training. Some of that is going to spin off, and if they go someplace else, they are still going to comment, as many of you have, "I was a teacher once, and I remember so-and-so," and they will be interested in looking at the school districts.

I think it is a wonderful idea.

Mr. BOEHLERT. How about you, Dr. Murphy?

Dr. MURPHY. Very much the same enthusiasm for the idea, and I have to comment. I think probably a lot of States are in New York's situation, where we have a declining number of people training to be teachers. I think one year in New York State, the largest public university system in the State, ours, graduated one physics teacher.

The declining number of people going into teaching, those that are going into teaching are at the bottom of their class, and so we have fewer people, of lower quality going in, and we are about to have an enormous amount of retirements, and the aging of our teaching population, the post-World War II group is in the fifties, and we are going to lose a lot of those people, and we are going to have a major crisis in education just getting bodies, never mind that, you know, they're qualified.

We have to do dramatic things, such as you are proposing. That is the point I want to make.

Mr. BOEHLERT. Thank you, Mr. Chairman.

The CHAIRMAN. The Chair recognizes the distinguished gentleman from Tennessee, Mr. Tanner.

Mr. TANNER. Thank you very much, Mr. Chairman. For either or both of you, would you comment on the Tennessee, I think, experience Dr. Newman alluded to earlier? Has there been discussion about it in either of your States?

Dr. BERGIN. We have a career ladder in Texas, and we have had a lot of—the career ladder, by the way, was part of the total reform movement passage along with the curriculum. Then there were also peripheral areas and one of them was teacher salaries and then the career ladder.

The career ladder in Texas is attached to the teacher assessment. Now the difficulty with the career ladder has not so much been in terms of concept. I think that there is very, very good agreement that teaching should be something where you could move one point to another point, and there might be things that would—expectations along the way for moving from point A to point B and C.

The political difficulty has been in the assessment instrument that is used and the fairness of that assessment instrument, because at some point, you have to have either something that is down on paper and it is checked off, or there is a paragraph written, but there is something that has got to document performance of the teacher in the classroom.

So with that, the way that the difficulties and the criticisms still continue to exist, but I think that there has been a stabilizing effort that, as long as the perception is that the way the assessment is carried out, it is not going to be arbitrary or capricious on the part of the administrator, that there are some safeguards built in and the teachers have an opportunity to look at that and to look at the assessment and comment on it. And they have also had a great of input in our teacher organizations in designing the instrument itself. The number of times that the teacher is to be observed in the classroom, and is that observation to be one where it is just a surprise and the administrator walks in and surprises them or tells them that on May 2 at 9 o'clock, I will be in and observe you.

Those are the kinds of things that have kept the anxiety levels up,

In theory, though, and I think in practicality, both teachers and principals are telling us that they have seen over the past two years a tremendous improvement in the quality of teaching as they are observing it in the classrooms.

So you have good and you have bad, and I think you are always going to have some kind of criticism about the fairness about how any kind of statewide evaluation is carried out. I don't see how you can do without that.

Mr. TANNER. Dr. Murphy.

Dr. MURPHY. We do not have a statewide program in New York, and I really don't consider myself qualified to comment on the Tennessee program.

Mr. TANNER. The earlier question I asked of Dr. Newman in regard to just the amount of time that our children in this country go to school as opposed to some of the other industrialized Western nations. Comment?

Dr. BERGIN. Well, time is probably one of our most precious resources in the classroom.

Mr. TANNER. You mentioned, I think, 360 minutes a day.

Dr. BERGIN. Minutes a day. That is about the time that a teacher has access to a student. Now much you get in there, and we certainly found that out when we looked at our statewide curriculum, and we began saying, well, let's see, if you take 120 minutes out for the language arts, and then if you say 60 for math and 45 for this and 15 and—you know, if you just kind of try to equate it out, you pretty much fill up the day.

The other aspect of this, for everyone that is involved in education is, what is it that is it that is expected of the public schools today? Because not only are we expected to deal with things like the mathematics and the science and the reading and the humanities, et cetera, but we are also looked at to deal with social issues, issues of segregation, AIDS, drug abuse, teenage pregnancies. The list goes on, and all of that is expected to be included in the 360 minutes.

So the issue of a 175 or 180-day school year and then a 360-minute day is, I think, one that merits looking at, but at the same time that you are looking at that, what you do during those minutes, what you said a little earlier, we are looking to improve science education by teaching science, and perhaps we haven't been doing that before. So once you say, well, now we're going to look at teaching the content area, we want to make sure that that's improved.

Mr. TANNER. I guess my question is, is 360 minutes a day for 180 days enough, in your opinion?

Dr. MURPHY. While Dr. Bergin is thinking, let me offer this kind of an answer. We do not make good use of the 180 days, the 360 minutes. I mean, there is a lot of research that shows in a 40-minute period, there could be as little as 5, 10 or 15 minutes of time on task, where there is good solid instruction occurring.

One of the things we should is work with teachers and try and improve the use of the time which we now have available to us. We could double the amount of good instructional time without changing the calendar, without changing the length of the school day or the school period, just by making more effective use of it.

We are looking at the programs going into the summer, particularly for at risk kids. Maybe—it is very, very expensive to extend the school year. We argue that, but you have a huge capital investment that lies idle. And we are looking at alternative ways to make more use of all those excellent school buildings and other facilities.

Mr. TANNER. There are some that really question whether that is enough time.

One other question, if I might, Mr. Chairman. I haven't heard anyone this morning comment on class size. I am a proponent of reduced class sizes, particularly in K-3. Without going into a long soliloquy, I have a theory about the fact that we try to put icing on the cake as relates to funding for higher education before we bake the cake, which is done in K through perhaps 6 or 7, and I don't think we give enough attention there, but that is another whole issue entirely.

Class size. Your comments on reduced class sizes and how important is that as it relates to the priority of funding.

Dr. BERGIN. At the primary level, four years ago, when we were mandated to reduce class size to 22 to 1 at the primary level, I think I could have given you an argument both ways, based on the research. Some say it does make a difference, some say it doesn't. But based on our experience, we are finding that it does make a difference, that those smaller classes at the primary levels do make a difference. At the other end of the spectrum, when we are looking at classes in our basic areas, in our core areas in English language, arts and mathematics at the high school level, and we wanted to do something like applied science and trying to do something that would compare a vocational course with science and with mathematics, so that the student would learn through hands-on experience, and there we are finding that it is also very helpful if we can reduce class size.

Dr. MURPHY. We do not have any requirements at the State level mandating a particular class size. Dr. Bergin commented that you could take any position you want and support her research. I think intuitively it makes sense that the fewer youngster that a teacher has, the better job he or she is going to do. If, when you reduce class size, say, from 30 to 20, you change the nature of the instruction. If you teach the class of 20 just as you did the class of 30, you are not going to see many improvements.

And I also want to reinforce a point I made earlier about the use of technology. We don't yet know how to integrate technology into the classroom, and that has a tremendous potential for individualized attention or small groups working around computers. If you look at what happens in industry or in a factory, when they go to automation, move in computers, the whole environment changes. In fact, they build new buildings. They start from scratch. What we do is, we reel in three or four computers in a classroom, and it is essentially the same structure, the same thing.

That is where I talk about the federal funding of studies to find out how do we change the job of teaching, when we take full advantage of technology? We have hundreds of thousands of computers already. I mean, I'm not saying we've got enough, but the problem is figuring out ways to get productive use out of what we already have.

Mr. TANNER. Thank you very much, Mr. Chairman.

The CHAIRMAN. We want to thank you both very much for your testimony. I am just writing that note down. I think it is an important one. In other words, you are saying what kind of added funding or demonstration could we apply for figuring out how we can get some optimum yield out of the existing equipment we have, as far as teaching is concerned.

Dr. MURPHY. Okay.

The CHAIRMAN. And I am sorry, we don't have more time this morning, because we would all like to hear more from you.

We do have a set of questions, if you don't mind, that, we didn't get to this morning, we would like to submit to you.

Dr. MURPHY. Sure.

The CHAIRMAN. If you would help us and fill it out, we would appreciate it. No further questions. We want to thank you very much for being with us.

And the committee stands adjourned for today.

[Whereupon, at 12:05 p.m., the hearing was adjourned.]

SCIENCE AND MATHEMATICS EDUCATION

WEDNESDAY, MAY 24, 1989

U.S. House of Representatives,
Committee on Science, Space, and Technology,
Washington, D. C.

The committee met at 9:40 a.m. in Room 2318 of the Rayburn House Office Building, the Honorable Robert A. Roe, Chairman, presiding.

Present: Representatives Roe, Walker, Brown, Scheuer, Lloyd, Boehlert, Walgren, Ritter, Packard, Hall, Fawell, Valentine, Smith, Morella, Campbell, McMillen, Price, Nagle, Skaggs, Costello, Johnston, and Browder.

The Chairman. The Committee will come to order.

The Chair would ask, without objection, permission is granted, for coverage of this meeting by television, radio, and still photography.

No objection, so ordered.

The Chair wants to welcome our members and also make an opening statement, a couple more, and then we'll get on with welcoming Admiral Watkins, our Secretary, who is with us this morning. We appreciate your spending the time.

First of all, last month this Committee held hearings, as you know, on the role of science and technology in creating the new role for America necessary to maintain our standard of living. New scientific and technical knowledge is the basis for new commercial products and services which we need to sustain to improve our economic health.

In addressing science and mathematics education again this morning, we come to the issue which underpins our entire science and technology enterprise and therefore will largely determine the future economic strength of our nation. The effectiveness of science and mathematics education in our schools will largely determine whether or not we produce the scientists and engineers who create new knowledge and the technology-literate work force which must transform that knowledge into useful products and services.

This is our second day of hearings on science and mathematics education in the United States. Yesterday we focused our attention on efforts underway in the states to upgrade science and mathematics curricula, to improve teacher performance, and to introduce new information technologies to the classroom. Today we turn to the consideration of Federal programs targeted at improving precollege and undergraduate science and mathematics education.

We are pleased to have distinguished representatives from six Federal agencies which support significant science education efforts with us today. We look forward to a review of current programs and future plans, as well as a discussion of interagency coordination and collaboration.

The presence of Admiral Watkins, the Secretary of our Energy Department, who really doesn't have the direct R&D as far as education are concerned—is here this morning and we want to welcome him and recognize that his background knowledge in the areas in which he intends to lead his department are essentially important to science education as the foundation for achieving our national technological goals.

I much regret on a bit of a sour note, however, that the Department of Education is not represented this morning among the Federal agencies here because, not on the part of lack of trying on our part, but apparently the Secretary felt it was not important that he would meet with this Committee this morning, but did agree to send two holdover Undersecretaries in the previous Administration, which we did not think would enlighten us or at least show the direction of the areas that this Committee is interested in going in 1989 and in the future, at least for this Administration.

So having said that, the Chair will now defer to the distinguished gentleman from New York, Mr. Boehlert.

Mr. BOEHLERT. Thank you very much, Mr. Chairman. I want to congratulate you for holding this hearing, which is the first comprehensive look Congress has taken at what is being done, and what can be done to improve science and math education.

In the spirit of bipartisanship, I, too, wish to express disappointment that the Department of Education was unable to send an acceptable witness. Last time I checked, the primary mission of the Department of Education was to be concerned with education, but perhaps we can hear from them at a later time.

I agree with you that the arrangement the Department offered, trading the Secretary for two Acting Assistant Secretaries and a policy to be named later, was not adequate for our purposes. Our purpose is to help determine and guide the education policy of a new President and a new Congress that have proclaimed their aspiration to be remembered for their innovations in that field.

I, as you know, have a bill that I think could be an important contribution: H.R. 1293 would offer federal scholarships to top juniors and seniors majoring in science, math and engineering on the condition that they teach two years at the pre-college level in return for each year they receive aid. The bill has been marked up in Subcommittee and has been introduced in the Senate, and I look forward to our Full Committee mark up next month.

Our witnesses yesterday heartily endorsed the bill and offered the best arguments for it. As Dr. Bergen and Dr. Newlon pointed out, the most important factor of determining the quality of education and the level of student interest is the quality of our teachers; everything else is just icing on the cake.

And Dr. Murphy, from the New York State Department of Education, presenting the frightening statistics: more teachers leaving the profession than can be replaced, and new teachers tending to come from the lowest academic ranks of their classes. I can think of no more significant step that this Committee could take than to attract more bright, competent, inventive teachers.

Thank you, Mr. Chairman.

The **Chairman**. I thank the distinguished gentleman.

The Chair recognizes the distinguished gentleman from New York, Mr. Scheuer.

Mr. **Scheuer**. Well it's a great pleasure to welcome Admiral Jim Watkins here today. He has proven that he is perhaps the Renaissance man of this Administration, and his commitment to education and his commitment to raising the sea to raise all the ships has been proven time and time again during his extraordinarily distinguished government service.

His having accepted to come here this morning makes even more bizarre and incomprehensible the refusal of the Department of Education to unleash its new Cabinet Secretary.

President Bush told the country that he wants to be an education president. I believe President Bush. I knew President Bush, Mr. Chairman, as you did, when he was still with us in Congress. He's a man of great distinction, great intellect and great honor.

And I find it extraordinarily difficult to understand how he could be undercut by his Secretary of Education, who would refuse to come up here and who would want to substitute for the new look, the new breadth, the new vision, a couple of subcabinet holdovers from the last Administration that failed pitifully to meet the education challenges that this country has faced over eight years. I find that extraordinary.

And I find that the lack of accountability for this thing, for this kind of lapse on the part of a Secretary of Education, who turns down this outstanding forum, is crippling this Administration. It's adding to the public view that this Administration has no goals, has no vision, is floundering. That's not fair to President Bush—he's a man of great vision, I believe.

And I can't understand how one of his significant Cabinet Secretaries could pass up this kind of an opportunity to join Admiral Watkins before this Committee in etching their vision of the education of Americans in science, math, and engineering, one of the most critical problems facing our country. It's a great pity, it's a disservice to the President, it's a disservice to the Administration, it's a disservice to the American people.

I congratulate Admiral Watkins for coming here. His extraordinary record of public achievement honors him and honors the rest of us and I look forward to hearing from him.

The **Chairman**. I thank the distinguished gentleman.

The Chair recognizes the distinguished gentle lady from Tennessee, Mrs. Lloyd.

Mrs. **Lloyd**. I thank the Chairman for yielding, and I ask unanimous consent that my opening remarks be made a part of the record.

I do want to welcome Admiral Watkins, Mr. Stephens and Ms. Joseph to our hearings today.

Mr. Chairman, I think it's very appropriate that our lead witness today is Admiral Watkins. Although he's been in office only a few months, he has already been identified as a leading advocate for science and math education for our nation's young people.

And I must tell you that I held hearings on this topic in Chattanooga, Mr. Chairman—and Ms. Joseph was present and was an outstanding witness—and one of the things that we covered was the role of the national laboratories in science and math education. Indeed, they can play a very large role; they have the capabilities.

But as I found in these hearings, Admiral Watkins' leadership and enthusiasm was already being felt in the national laboratories and the exuberance displayed by the labs, I think, is really indicative of the leadership of Admiral Watkins.

I congratulate you, and I welcome Admiral Watkins. Thank you.

[The prepared opening statement of Marilyn Lloyd follows:]

HONORABLE MARILYN LLOYD
SCIENCE, SPACE AND TECHNOLOGY COMMITTEE
HEARING ON
SCIENCE AND MATHEMATICS EDUCATION

MAY 24, 1989

WE STAND TODAY ON THE EVE OF THE 21ST CENTURY. AS WE APPROACH THE LAST DECADE OF THE 20TH CENTURY, WE FIND OURSELVES FACE-TO-FACE WITH A CRISIS THAT MAY WELL LAST INTO THE NEXT CENTURY. THIS SITUATION THREATENS OUR NATION'S STANDING IN THE GLOBAL ECONOMY.

TODAY'S HEARING ADDRESSES AN IMPORTANT TOPIC THAT WILL HAVE LONG-TERM IMPLICATIONS FOR OUR NATION AS WE MOVE INTO THE HIGH TECHNOLOGY WORLD OF TODAY AND THE FUTURE. THIS WORLD IS HIGHLY COMPETITIVE. THE WINNERS IN THESE ECONOMIC AND TECHNOLOGICAL COMPETITIONS WILL BE THOSE WHO POSSESS THE SCIENTIFIC AND ENGINEERING SKILLS AND WHO BRING THESE TO BEAR MORE EFFECTIVELY AND MORE QUICKLY THAN THEIR COMPETITORS.

OUR CONCERN IS THAT WE ARE ENTERING THIS COMPETITION AT A

DISADVANTAGE. WE ALREADY HAVE A SHORTFALL OF SCIENCE, MATH AND ENGINEERING GRADUATES, AND IT WILL TAKE YEARS TO FULLY TURN THIS TREND AROUND. OUR STUDENTS ARE TURNING AWAY FROM THE VERY DISCIPLINES THAT ARE CRUCIAL FOR SUCCESS. AT A RECENT FIELD HEARING WHICH I CHAIRED IN CHATTANOOGA, WE LISTENED TO HIGH SCHOOL AND JUNIOR HIGH TEACHERS AS THEY TOLD US "OUR STUDENTS ARE 'TURNED OFF' OF SCIENCE AND MATH BY THE TIME THEY REACH HIGH SCHOOL. WE ARE LOSING THEM IN THE GRAMMAR SCHOOLS." THIS IS INDEED DISCOURAGING.

BUT THERE ARE INDICATIONS THAT NEW APPROACHES AND NEW IDEAS ARE BEGINNING TO HAVE SOME EFFECT. THE DEPARTMENT OF ENERGY AND OUR NATIONAL LABORATORIES HAVE DEVELOPED A NUMBER OF INNOVATIVE PROGRAMS TO REACH BOTH STUDENTS AND TEACHERS. THESE PROGRAMS ARE TRYING TO REKINDLE IN OUR STUDENTS AN INTEREST IN SCIENCE, ENGINEERING AND MATHEMATICS. FOR OUR TEACHERS, IT PROVIDES INFORMATION ON NEW DEVELOPMENTS TO HELP THEM KEEP UP WITH AN EVER-CHANGING WORLD, PLUS IT GIVES THEM ACTUAL RESEARCH AND LABORATORY EXPERIENCE TO TAKE BACK TO THE CLASSROOM.

I BELIEVE IT IS VERY APPROPRIATE THAT OUR LEAD WITNESS FOR TODAY'S HEARING IS THE SECRETARY OF ENERGY, JAMES WATKINS. EVEN THOUGH HE HAS

BEEN IN OFFICE BUT A FEW MONTHS, HE HAS ALREADY BECOME IDENTIFIED AS A LEADING ADVOCATE FOR SCIENCE AND MATH EDUCATION FOR OUR NATION'S YOUNG PEOPLE.

AS WE FOUND IN OUR HEARINGS IN CHATTANOOGA, ADMIRAL WATKINS, YOUR LEADERSHIP AND ENTHUSIASM HAVE ALREADY BEEN FELT AT THE NATIONAL LABORATORIES. THE EXUBERANCE DISPLAYED BY THE LABS FOR THEIR EDUCATIONAL PROGRAMS REFLECTS DIRECTLY ON YOUR COMMITMENT. WE LOOK FORWARD TO HEARING YOUR TESTIMONY ON THIS VITAL TOPIC.

The **Chairman**. I thank the gentle lady.

The Chair recognizes the gentleman from Illinois, Mr. Fawell.

Mr. **Fawell**. Thank you, Mr. Chairman. I, too, want to congratulate you for having these hearings and look forward to the testimony of Admiral Watkins. The importance of science and math education is something that we are looking into. I happen to be a member of the Education Committee. I regret that Secretary Cavasos is not here; I do believe he is intensely interested in this hearing, however.

And as a Member of Congress wherein Fermi Lab is right next door and Argonne is in the district, I do know that we're blessed by having those entities.

And I might add that Leon Letterman, who is now retiring as the Director of Fermi, was, in fact, the man who was instrumental in bringing the Illinois Math and Science Academy to Illinois, one of the finest such institutions in the entire country—just as an example of what happens when you have indeed these federal institutions, these labs that bring so much just in terms of having high quality people, science and math people and engineers in the area.

So I do look forward very much to your testimony, Admiral Watkins.

And, once again, Mr. Chairman, I do appreciate the fact that you have led in having these hearings brought about.

The **Chairman**. The Chair thanks the distinguished gentleman from Illinois and recognizes the distinguished gentleman from Pennsylvania, Mr. Walgren.

Mr. **Walgren**. Thank you, Mr. Chairman.

And I would just like also to welcome the witnesses here today to talk about what is perhaps the most important problem I think we have in the future of science and technology and in fact the standing of our country in the long run.

As some of you know, this Committee has been interested in—and particularly my Subcommittee—scholarships for science and math education for high school graduates. We introduced a bill last year. The President specifically called for science and math scholarships for high school graduates in his State of the Union address.

And I think it's particularly unfortunate that the Department of Education witnesses are not here today because the President's proposal places that function in the Department of Education.

Our Committee has worked up a bill in which we have emphasized the role of the National Science Foundation in the administration of that program. And somehow or other the Congress has got to be sure that these programs are designed in the most effective way.

We, as Congressman Boehlert indicated, have one part of that program specifically designed for people who then go on to be accredited as teachers. There are other parts that are designed to provide incentives for people to go to graduate school and also to provide very direct models for both the young men and the young women on a broad geographic basis, based two nominees in each Congressional district, that we hope will make an important contribution to creating the kind of interest in science and math education that we're going to need if we're to succeed.

The Department of Energy and the National Institutes of Health, along with the National Science Foundation, have been key players in what we have done as a country for starters. In many ways the Department of Energy and NIH have been where the money was, and they have tried to make some very specific efforts in this area.

The National Science Foundation has had a traditional role in the education of graduate students ever since it was chartered in 1950. But, we have to realize that we are spending today at the National Science Foundation, on science and engineering education, less than one-half of the effort that this country made through the National Science Foundation on science and engineering education in the mid- 1960's.

And we have to ask ourselves, is one-half the effort that we were able to make in the mid-1960's in science education enough to protect the future of this country and to secure what this area must contribute to the national interest.

Mr. SCHEUER. Could I—

Mr. WALGREN. Mr. Chairman, I want to thank you for holding these hearings and particularly getting us onto the level of the other major agencies that have been good players in this area and express my appreciation for that.

I'd like to yield to the gentleman from New York.

Mr. SCHEUER. When you mentioned that we're doing half of what we were doing 25 years ago, is that in real dollars or is that in—

Mr. WALGREN. That's in what we call constant dollars. The dollars actually are in—if we were to take 1965 dollars and adjust them for inflation, we would be spending something in the range, in the National Science Foundation alone, of $325 million in science and engineering education. We are spending $176 in the fiscal year 1989.

Mr. SCHEUER. Because if it hadn't been in real dollars, we would be spending about a sixth instead of a half.

The CHAIRMAN. The Chair recognizes the distinguished gentleman from Pennsylvania, our ranking member, Mr. Walker.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. Chairman, I'd like to express my personal gratitude to Admiral Watkins for taking the time to share his views with us on the Department of Energy's role in math and science education.

Mr. Secretary, your presence here reinforces the high level of importance this Committee places on this subject and the importance of math and science education to the future of this nation. In your first appearance before this Committee, I'm pleased by the outstanding reports that your efforts are having within your own Department and, therefore, for the nation. You are to be commended for the leadership role that your Department has established.

I say that in direct contrast to the situation that we find ourselves in today with regard to the Department of Education. I am very disappointed that Secretary Cavasos could not find the time to come and appear before this Committee.

I, along with the Chairman, made a personal plea to Secretary Cavasos to be a part of this hearing. I was not even given the courtesy of a return phone call, or no one was ever in touch with me to explain why Secretary Cavasos could not come to this meeting.

I am disappointed by that, I think that the math and science education front is one that the Department of Education, as well as the Department of Energy, the National Science Foundation and everybody else has to be directly involved in.

I appreciate our opportunity to meet with Admiral Watkins here today. I am very disappointed the Secretary of Education would not afford us the same opportunity.

The CHAIRMAN. I thank the gentleman from Pennsylvania.

Are there any further opening comments at all?

[No response.]

The CHAIRMAN. If not, the Chair takes the opportunity now to recognize our distinguished first witness, the Honorable James D. Watkins, Secretary of Energy. And he is accompanied by Ms. Joseph and Mr. Stephens. So without further ado...

Secretary Watkins, your statement will appear in full in the record, if there's no objection, which I'm sure there's none. Then you can either summarize or do exactly what you want to do. We'd like to hear from you very much.

STATEMENT OF ADMIRAL JAMES D. WATKINS, SECRETARY, DEPARTMENT OF ENERGY, WASHINGTON, D.C., ACCOMPANIED BY MS. TONI GRAYSON JOSEPH AND MR. RICHARD STEPHENS

Secretary WATKINS. Thank you very much.

Mr. Chairman, members of the Committee, I am grateful for the opportunity to be with you today to talk about a subject that is very important to me as Secretary of Energy, but also very important to me personally: the education of America's young people.

With me today are two members of my staff, Ms. Toni Grayson Joseph and Mr. Richard Stephens, who supervise DOE's education programs.

I know that many members of this Committee are fully familiar with the impressive work that the Department of Energy is doing in science and engineering education. Several of you have DOE labs in your districts, as mentioned by Mrs. Lloyd, and know the value of our hands-on research support of science education.

Mr. Chairman, I have prepared a report on our programs which has been submitted to the Committee, and I request that this report be included in the record as part of my testimony.

The CHAIRMAN. With no objection, so ordered.

[The report follows.]

Department of Energy
Washington, DC 20585

REPORT ON DEPARTMENT OF ENERGY SCIENCE AND ENGINEERING EDUCATION PROGRAMS

SUBMITTED BY

THE HONORABLE JAMES D. WATKINS
ADMIRAL, U.S. NAVY (RETIRED)
SECRETARY OF ENERGY

AT A HEARING ON

MATHEMATICS AND SCIENCE EDUCATION

BEFORE

THE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

MAY 24, 1989

2318 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, D.C.

SUBMITTED TESTIMONY OF

THE HONORABLE JAMES D. WATKINS
ADMIRAL, U.S. NAVY (RETIRED)
SECRETARY OF ENERGY

Outline

Page:

Introduction. 1
- History of DOE Support for Science Education
- DOE Mission in Science and Engineering Education
- Budget Authority and Laboratory Resources
- Historic Focus: Graduate and Postdoctoral Education

I. **Precollege Science Education Programs** 4
- PreFreshman Engineering Program (PREP)
- High School Research Apprenticeships
- International Science and Engineering Fair
- High School Science Student Honors Research Program
- High School Science Teachers Research Associates Program
- Middle School Nuclear Energy Curriculum
- Museum of Science and Industry Renovation
- Informal Precollege Science Education Programs

II. **Undergraduate Science Education Programs**. 8
- Student Summer Research Participation Program
- Science and Engineering Research Semester
- Undergraduate Student Research Projects
- Faculty/Student Research Teams
- Used Scientific Equipment Program
- Laboratory Outreach to Small Colleges and Universities

III. **Minority Education Programs** 11
- Historically Black College and University Program
- Laboratory/University Partnerships

IV. **DOE Laboratories and Science Education**. 13

V. **Program Evaluation Efforts**. 14

VI. **Coordination With Other Federal Agencies**. 14

VII. **Dissemination of Program Information**. 15

VIII. **Future Expansion and Direction of DOE Science Education Programs**. 16

IX. **DOE-Sponsored Science Education Conference**. 17

Conclusion 17

APPENDIX: Schematics

Mr. Chairman, and Members of the Committee, I am pleased to address the Committee on what I believe is one of the most serious problems facing the United States over the next ten years; namely, the declining quantity of young Americans, including minorities and women, interested in pursuing careers in science, mathematics and engineering, compounded by the often woefully inadequate preparation received by young students interested in such careers. Much of my career has been concerned with how we can best encourage and prepare our young people for careers in an increasingly complex and technologically driven global society. Given the important mission the Department of Energy carries in science and engineering education, one of my challenges as the Secretary will be to do what I can, both personally and through the Department, to improve science education in our nation.

History

DOE has had a long tradition of support for and involvement in science education, going back to the very earliest days of the Atomic Energy Commission (AEC). This tradition of support has not been fully recognized or appreciated, however, outside of the Department's own network of National Laboratories and university grantees. For example, AEC was one of the first Federal agencies to support graduate research fellowships in key scientific areas such as nuclear medicine, that have had enormous benefit to mankind, and in important engineering disciplines that have enabled America to remain at the cutting edge of technology worldwide. Many of today's scientific and technical leaders in the energy industry, the National Laboratories and the university community began their research careers with graduate student support from the AEC. Support was provided by the AEC for undergraduate student summer research and for related faculty research beginning in the late 1950's. Some precollege student and teacher science education programs were initiated in 1962 by AEC. This tradition of support for science education continues today at DOE.

The Department of Energy's Mission in Science and Engineering Education

The Department of Energy is uniquely positioned to provide major assistance to the national effort to strengthen science and engineering education. For example, several of our laboratories are "Centers for Excellence in Science Education," and it is our plan to expand that program and include the site of the Superconducting Super Collider as one such center. Our efforts complement those of the National Science Foundation and the Department of Education, state and local governments and the education community by providing students and their teachers with "hands-on" research experiences in ongoing, cutting edge scientific and technical research. The Department is providing such assistance today, and we will do even more in the future.

Before I describe the Department's current programs in science education and our plans for the future, let me place this in the context of the Department's overall responsibilities and missions. Simply stated, the missions of the Department of Energy are to support fundamental scientific research on energy and matter, carry-out energy-related research and technology development in specific technical areas, conduct research and engineering development related to national security and ensure that all DOE programs are carried out with specific attention to environmental and public health concerns.

Budget Authority and Laboratory Resources

Collectively, DOE is a significant national resource in science, mathematics and engineering. Our FY 1990 budget request is for $15 billion in budget authority, including $6.2 billion in science, energy and defense-related R&D and an additional $7.3 billion in engineering development work related to national defense production and support, environmental restoration and waste technology.

In order to carry out these missions, DOE is a both a user and a patron of a large fraction of the nation's scientists and engineers. The Department manages a complex of over 50 contractor-operated research laboratories employing in excess of 135,000 people.

Within this complex, nine multiprogram National Laboratories and thirty specialized laboratories carry out much of the Department's fundamental scientific research and energy technology R&D and all of the Department's national defense-related R&D. These latter facilities account for slightly more than 40% of the Department's total field budget and employ over 60,000 people, more than half of whom are scientists, engineers and technicians. DOE, through its National Laboratory and university performer base, is responsible for research in almost every scientific and technical discipline.

Our ability to meet the many pressing challenges facing the Department today and in the future will ultimately depend on the scientific creativity and technical skills of our workforce. All science-based agencies and organizations, whether public or

private, must redouble their efforts to attract more young people into scientific and technical careers and to ensure that they receive the highest quality education and training possible.
I now would like to describe in some detail DOE's current support for science education, addressing in turn the Committee's questions in the charge letter, and then discuss additional steps we plan to take in the future.

Historic Focus:
Graduate and Postdoctoral Education

The historic focus of DOE support for science education has traditionally been at the graduate and postdoctoral levels. The principal means by which this is accomplished is through the support of university research by DOE which totals approximately $400 million in FY 1989. This support also funds the participation of 3500-4000 graduate students. In recent years, expanded support has also been provided for precollege and undergraduate-level science education programs. For reference by the Committee, I am attaching a list of the current precollege and undergraduate science education programs supported by DOE, many of which will be discussed further in the following section. I am also attaching a schematic showing where our current programs are targeted on the education pipeline.

What underlies all of our science education efforts is the belief that it is essential to extend the classroom experience by exposing young students to real science as early as possible in their careers.

DOE support for science education includes both formally funded programs as well as a vast range of volunteer and informal assistance provided by many thousands of DOE-supported scientists and engineers to local schools and colleges. Science education is everybody's responsibility in the Department. I am directing both Department and contractor staff to redouble their efforts in supporting both formal and informal science education activities.

A central organizational focus for DOE's formal support of precollege and undergraduate science education programs is provided through the Office of Energy Research, specifically the University Research Support Program. In FY 1989 approximately $12 million will be provided through this program for precollege and undergraduate science education.

An additional $13 million is also provided by DOE for programs with Historically Black Colleges and Universities and other minority institutions, almost all of which is directed at the undergraduate level.

I. DEPARTMENT OF ENERGY PRECOLLEGE SCIENCE EDUCATION PROGRAMS

The strength of DOE's precollege science education programs lies with the scientists and engineers who work for DOE in universities and the National Laboratories. Exposing students and their teachers to "live science" in a research laboratory can ignite the interest and intellectual curiosity of the students and can vitalize and revitalize teachers and the members of the teaching profession. Even informal encounters with research scientists and engineers can be pivotal in stimulating young people to pursue careers in science and engineering. Therefore, the Department's current precollege science education programs focus on:

> Encouraging more young people to enter into and stay in the science/engineering manpower pipeline; and

> Strengthening the capabilities of precollege science teachers to motivate and excite young students about the opportunities and challenges of scientific and technical research.

The Department's precollege programs are:

PreFreshman Engineering Program (PREP). The PREP program provides support for summer enrichment institutes on engineering and related subjects for women and minority 7th to 10th grade students. These institutes are conducted on-campus and provide the participants with a number of pre-engineering enrichment experiences including laboratory work, field trips,career counselling and tutoring in mathematics. The overall purpose of PREP is to encourage the young participants to consider careers in engineering and related fields.

Over 2000 students participate in PREP projects located at campuses across the country. Statistics indicate that over the years 60% of the student participants have historically enrolled in college-level engineering or science programs. Some individual PREP projects have reported that over 80% of their participants have gone on to major in engineering or science in college. The project director of the PREP effort at Case Western Reserve University reports that 97% of the former PREP participants are now in college and 72% have enrolled in engineering.

One former PREP student's experiences are typical of what has happened to many of the participants in this program. Ms. Julia Mireles from San Antonio, Texas was a former participant in the PREP project at the University of Texas, San Antonio. She has since completed a degree in chemical engineering from Texas A&M University and is now employed as a chemical engineer by the City of San Antonio. She credits her PREP experience with helping her realize that engineering was exciting and for her.

High School Student Research Apprenticeships. The Apprenticeship program is conducted at five DOE National Laboratories and is designed to motivate freshmen and sophomore high school students to pursue scientific or technical careers. The Apprenticeship program centers around laboratory research experiences along with counselling and tutoring. About 130 students (over 90% are women and minorities) are involved in this program each year at the participating laboratories.

International Science and Engineering Fair. Each year DOE, along with many other Federal agencies and private companies, participates in the annual International Science and Engineering Fair. This Fair involves over 2000 high school science students who have prepared exhibits on science-related research projects. DOE selects the top ten energy-related science exhibits and awards the winning students, along with their teachers, a week-long research and educational experience at a DOE National Laboratory. In 1989 the student winners will spend a week at the Idaho National Engineering Laboratory learning about the many exciting technical challenges we face in nuclear power technology.

DOE High School Science Student Honors Research Program. Beginning in 1985 DOE has provided opportunities to the nation's very best high school science students to participate in hands-on summer research at DOE laboratories. Students are selected for participation in this Honors Research program by the Governors of the respective states (including Puerto Rico, American Samoa and the District of Columbia). During the summer of 1989 there will be seven individual Honors Programs with 374 students participating.

Each of these programs concentrates on a different area of science as follows: synchrotron radiation research (Brookhaven); life sciences and genetics (Lawrence Berkeley); supercomputers and computational science (Lawrence Livermore); environmental research (Oak Ridge); materials sciences including supercon-superconductivity (Argonne); particle physics (Fermilab); and marine and semi-arid ecosystems (Pacific Northwest Laboratory). All of the former participants in the Honors Program have gone on to college. Over 75% are proposing to major in science or engineering with the remainder split among law, business and medicine. Many of the former Honors students return each summer to a DOE laboratory to continue their research experiences.

Alan Fry from Pocatello, Idaho was in the first class of DOE Honors students in 1985 at the Lawrence Livermore National

Laboratory. Alan is now majoring in physics at the University of Utah and has spent each subsequent summer at Livermore working in such areas as computational physics, designing X-ray spectrometers and participating in high energy physics research. Alan returns to Livermore once a month during the current academic year to work on an individual research project for his senior honors program at the University.

High School Science Teachers Research Associates Program. High school science and mathematics teachers are nominated by each State to participate in a special eight week summer research program at selected DOE National Laboratories. We expect 150 science teachers in this program this summer. Each teacher will serve as a participating member of a laboratory research team and will use this experience to develop supplemental materials and experiments for use in the classroom. Many of the teacher participants will also be awarded graduate-level credit by regional universities for participating in this program. The experiences of one high school science teacher illustrate the benefit and implications of this program.

Pat Ehrman, a biology teacher at Davis Senior High School in Yakima, Washington used his summer research assignment at the Pacific Northwest Laboratory to develop a unique junior-level course in microbiology. The students in this course conduct university-level research including gene splitting and identification. Pat will spend the coming summer at the Lawrence Berkeley Laboratory further refining this course for eventual dissemination to other high schools across the country. Pat was also a 1988 Presidential Award Winner from Washington for excellence in science teaching.

One of the underlying motivations in our support for the Teacher Research Associates Program is to help remind science teachers that they are full members of the broad scientific and technical community. Precollege science teachers tend to be isolated from new developments in their disciplines within a few years after they leave college. They have few opportunities for keeping current in their fields or for developing the kind of collegial relationships with research scientists that can help enhance the status of the science teaching profession. This program helps reinvigorate these front line warriors in science education.

We also view the program as providing a great return on investment. It is estimated that every teacher we train reaches at least 150 students during the following school year, and 150 additional students each subsequent school year. Through this "multiplier effect," the science and engineering information and expertise can be widely disseminated.

Middle School Nuclear Energy Curriculum. In response to numerous requests from middle school teachers for information on nuclear energy, the Department's Office of Nuclear Energy has developed a complete nuclear energy curriculum designed for use at the sixth through eighth grade levels. Titled "**The Harnessed Atom**," this curriculum consists of reading lessons for students, a teacher's guide and a filmstrip with audiotape. The curriculum covers the basic principles of nuclear fission and deals with some of the common misconceptions about nuclear power. The curriculum kit is currently being distributed to teachers around the country both directly and through the voluntary efforts of many utilities, industrial organizations and professional societies.

Museum of Science and Industry. The Department recognizes the importance of informal, out-of-school activities in science education, and to this end, we are currently involved with the renovation of a major science and energy exhibit at the world-renowned Museum of Science and Industry in Chicago. This facility hosts school children from Chicago area schools. The renovated exhibit will include a new presentation on solar photovoltaic technology, featuring a 1.5 kilowatt state-of-the-art solar cell array donated to the Museum by private industry. The overall exhibition will also include teaching materials and other resources designed specifically for use in inner-city schools.

Informal Precollege Science Education Programs. The programs I have just listed are national DOE initiatives funded through the University Research Support Program. In addition to these formal efforts, there is a range of informal, volunteer-based science education activities carried out at each DOE laboratory and research contractor.

A survey conducted last year for us by staff at Fermilab indicated that there were over 200 individual precollege efforts underway at 23 DOE facilities involving 13,000 teachers and over 130,000 students. These efforts included in-house tours, visits and demonstrations at the laboratories for elementary and secondary school students and teachers, direct classroom instruction and assistance at local schools, science fair sponsorship and judging, teacher workshops and institutes, research participation programs and a number of special events centering around the annual National Science and Technology Week celebration.

For example, the Lawrence Berkeley Laboratory hosted 500 San Francisco Bay Area science students and teachers in a program on Global Climate Change on April 25 of this year while DOE Headquarters brought in 300 local area teachers and students on April 26 for a half-day of discussions and presentations on DOE programs in superconductivity, the human genome and particle physics. Four hundred students and their parents also participated in a program at the Fermi National Accelerator Laboratory led by local high school science students who performed a series of scientific demonstrations in a program titled **"The Wonders of Magic and Science."**

I also want to note how seriously we take the national "Adopted School" effort which is part of the President's Partnerships in Education Program. DOE laboratories and research contractors have formally adopted a number of local elementary and secondary schools over the last several years. For example, Oak Ridge National Laboratory has "adopted" the science departments at each of its local area high schools. Here at Headquarters, we have adopted Woodrow Wilson Senior High School in Washington, D.C.

These adopted school programs include such activities as DOE employees providing student tutoring and counseling, science fair judging, classroom lectures and assistance, summer research internships for teachers and students, support for extra-curricular science and math clubs, computer time and surplus equipment and materials loans.

I plan to significantly expand the Department's participation in the national adopt-a-school effort, including going beyond individual schools and working with entire school districts.

II. DOE UNDERGRADUATE SCIENCE EDUCATION PROGRAMS

The Department's support for undergraduate science education also is centered on providing students and faculty members with the opportunity to participate in "hands-on" research at DOE facilities. Undergraduate students are particularly important since experiences in participating in state-of-the-art scientific research directly influence their specific career choices in scientific and technical fields.

Specific programs in undergraduate science education are as follows:

Undergraduate Student Summer Research Participation Program. Each summer approximately 1100 undergraduate science and engineering students are competitively selected to spend a summer conducting research at DOE laboratories and research facilities. About half of these participants are from small, predominantly undergraduate institutions. The students work as members of laboratory research teams, often in conjunction with university faculty members. Student research assignments are carefully selected and monitored to ensure they are meaningful and at an appropriate professional level.

Evaluations of this program indicate that 90% of the participants go on to receive advanced degrees in science or engineering and that 65% of the participants indicate that their research participation experience greatly influenced their choice of career specialization.

These experiences can change lives as well as careers. Jeronimo Garay spent his days picking lettuce in the California Imperial Valley and his evenings in night school at a local community college. He was provided an opportunity to spend a summer at the Lawrence Berkeley Laboratory with a DOE research appointment from the Associated Western Universities. This experience led Jeronimo to apply to and be accepted by the University of California at Berkeley for full-time study in chemical engineering.

Science and Engineering Research Semester for Undergraduates. The National Laboratories provide an ideal environment in which to place a science or engineering student attempting to determine a career path. Six of DOE's multipurpose laboratories (Argonne, Brookhaven, Lawrence Berkeley, Los Alamos, Oak Ridge, and Pacific Northwest) make their resources available to undergraduate juniors and seniors for use during the academic year.

The DOE Science and Engineering Research Semester program is a national competitive activity which provides semester-length research opportunities for junior and senior college students majoring in science, mathematics or engineering.

In FY 1989 over 300 students will participate in this program from universities and colleges across the country, many of which are small non-doctoral degree institutions. Each student participates in an on-going research program at the host laboratory and learns to use sophisticated, state-of-the-art scientific equipment.

An example of the kind of research in which the students participate is high-temperature superconductivity. The students work directly with chemists, solid state physicists, materials engineers, thin-film specialists, and x-ray crystallographers. These research teams are on the cutting edge of technology, and provide a stimulating and unmatchable research experience for the students.

Undergraduate Student Research Projects. It is exciting to note how many young undergraduate science and engineering students are already capable of performing innovative research projects on their own, given the opportunity and the resources to do so.

One major example of this is the recent Methanol Marathon competition co-sponsored by the Department of Energy and the Society of Automotive Engineers. This project was established to foster the use of alternative fuels by supporting vehicle competitions among engineering students. Student teams were selected from fifteen engineering schools for the 1989 competition.

Each student group was given a new Chevrolet Corsica, donated by the General Motors Company, some elaborate computer hardware, and a methanol tolerant fuel tank. The students modified the Corsicas to optimize the use of methanol as an alternative fuel. All fifteen teams then competed in an 1100 mile road rally, with each team's entry rated on performance, fuel economy, acceleration, and rally times. The 1989 winning group was from the University of Tennessee.

Through this project, DOE stimulated 200 talented and eager engineering students and their university faculties to study the use of alternative fuels. Since each of the schools will retain their Corsica for future use and modification, we have also in a sense created fifteen new research facilities with the capability of future alternative fuel use study.

Faculty/Student Research Teams. DOE encourages faculty members, particularly at smaller institutions, to spend a summer or an academic year conducting research at a DOE facility along with one or more of their undergraduate students. There will be thirty faculty/student research teams at five different DOE laboratories this summer. These teams are important links between DOE laboratories and individual colleges. Faculty members tend to return each summer to the laboratory to continue their research bringing along a new group of students. Several campuses have made the faculty/student team program a major recruiting point with prospective students.

Used Energy-Related Scientific Equipment Program. Based on the legislation which established the Atomic Energy Commission, DOE has the authority to grant title to excess DOE-owned laboratory research equipment to universities, colleges and other non-profit institutions.

Over the years, this program has served as an important source of laboratory equipment for many smaller colleges and predominantly minority institutions. The equipment is awarded on a "first-come, first-served" basis. Information on available equipment is provided on a monthly basis in both a printed catalog and on a dial-up computer information system. The equipment can be used by the recipient institution for either research or instructional purposes with no prior or current DOE contracts or grants required.

There are times when a used research equipment grant can help refocus an institution's research and education programs. St. Cloud State University in Minnesota recently received title to an electron microprobe from the DOE Mound Laboratory. This microprobe is now used in a new minerals research program serving the entire upper Midwest.

Laboratory Outreach to Small Colleges and Universities. The DOE laboratories also provide a range of technical assistance and support to small regional colleges and universities. This can range from providing laboratory scientists as guest lecturers and adjunct faculty to advising on the set-up and maintenance of research equipment and instrumentation.

The Argonne National Laboratory has established a Regional Instrumentation Center where faculty and students from Midwest colleges can come to Argonne to use certain specialized instruments not normally found on many small campuses. This is in addition to the operation by Argonne and other DOE laboratories of major scientific user research facilities including synchrotron light sources, pulsed neutron facilities, electron microscopes, and environmental research parks, all of which are available for use by the scientific community.

III. MINORITY EDUCATION PROGRAMS

DOE Historically Black College and University Program. DOE is committed to strengthening the capabilities of the Historically Black Colleges and other minority institutions to participate in and contribute to the national research and education effort. DOE will provide approximately $13 million in FY 1989 to Historically Black Colleges for research and related education projects. This includes support for programs at both two and four-year colleges.

For example, the DOE Office of Minority Economic Impact has established a nationwide program in energy related technologies at eight two-year colleges. These technologies include computer sciences, electronics, and robotics. Support is provided for student assistance in the form of scholarships and tuition costs. Special attention is paid to recruiting and retaining students.

The Department also places strong emphasis on developing close and formal relationships among minority colleges and DOE research laboratories. Currently, there are 15 formal cooperative agreements between DOE laboratories and minority colleges. These agreements encompass such cooperative efforts as faculty and student research internships at the laboratories, technical assistance from the laboratories in the establishment of research programs and facilities at the minority schools, access to laboratory computers and specialized research equipment, collaborative research between laboratory and university researchers, and precollege minority student and teacher programs.

Examples of these formal relationships include:

DOE National Laboratory	Minority College/University
Lawrence Berkeley	Jackson State University Turabo University (Puerto Rico)
Lawrence Livermore	Alabama A&M University
Oak Ridge	University of Puerto Rico
Pacific Northwest	Southern University, Baton Rouge
Argonne	Chicago State University

Also, the unique "**Science Alliance Program**" involves three DOE laboratories and three minority institutions: Sandia, Los Alamos, and Oak Ridge National Laboratories, and New Mexico Highlands University, North Carolina A&T State University and Turabo University in Puerto Rico.

One of the unique features of the participation of the universities in Puerto Rico in this program is the support being provided by the Carnegie Corporation of New York for an extensive precollege science enrichment program involving over 300 junior and senior high school students each year. The students spend each Saturday at one of the universities participating in laboratory research, and each summer working on a research project. Over 95% of the graduates from this very special program have gone on to college, many on scholarships to mainland universities.

The joint program between the Pacific Northwest Laboratory and Southern University also has a precollege component. Financial and technical assistance is provided through the Laboratory to the University's Engineering Summer Institute and Retention Program. This effort is designed to introduce junior and senior minority high school students to careers in science and engineering and to provide engineering students with tutors once they enroll at the University.

Over time all of these formal relationships will greatly enhance the capabilities of these schools to participate in advanced scientific research and to better prepare their students for careers in science and engineering.

IV. DOE LABORATORIES AND SCIENCE EDUCATION

The DOE National Laboratories and research contractor labs form a national and regional network covering a spectrum of science education programs from elementary school to postdoctoral research, and are central to the Department's support for science education. Their range of activity includes outreach to early school years to stimulate and nurture interest in science, special programs at the upper precollege level to give students and their teachers a taste of "live science," and intensive research experiences for university students and faculty.

There are few places in this country that can equal the range of science education opportunities and resources available at a major DOE multiprogram National Laboratory -- "big science," disciplinary and multidisciplinary research, individual investigator and team research -- all coupled with world-class scientific facilities, equipment and technical support resources.

Even though thousands of scientists are currently invloved in education-related activities, the potential of these laboratories to provide major assistance to precollege and university science education has only been partially realized, and these efforts will continue to be expanded as part of the Department's commitment to science education.

Several of our laboratories have been designated as "Centers for Excellence" in science education. As stated earlier, the Department is designing the site of the Superconducting Super Collider in Texas as a National Center of Excellence in Science, Engineering and Mathematics Education. The SSC will be a national symbol of pride and excellence in U.S. science and technology, and can also serve as a "real-time" window into science, engineering and math for school children and their teachers, as well as college faculty and their students.

We view the SSC as a learning laboratory throughout its planning, construction and operational stages. The SSC facility will host school tours, sponsor conferences and workshops for science teachers, conduct supper science camps for young students, serve as a "hands-on" research laboratory for undergraduate and graduate students in such disciplines as geology, mining and civil engineering, electronics and electrical engineering, environmental science and socioeconomic disciplines. We will also look at the feasibility of linking the SSC when it becomes operational to schools and colleges across the country through remote access telecommunications technology. We plan to do all of this in a working partnership with the State of Texas, the SSC operating contractor, and professional societies and associations of science teachers.

V. PROGRAM EVALUATION EFFORTS

All of the Department's science education programs discussed above has a built-in and long-term evaluation component. Students who participate in our Honors Research Program will be tracked for at least five years beyond their participation to see what impact this research experience has had on their academic and career choices. Teachers participating in our summer research program will be periodically surveyed to see how their teaching skills and scientific knowledge has been enhanced.

Each year we carry out a five-year retrospective assessment of one of our major undergraduate or faculty programs wherein we see what has happened to an entire cohort of participants in these programs--degrees obtained, research initiated, careers refocused or changed, publications and so forth. We are also working towards the establishment of a major and ongoing data base of all the participants in our various science education efforts. Our goal is to ensure that students who enter into the DOE network of programs even as early as the middle school years are periodically informed of other opportunities facing them with DOE as they move on up the education pipeline.

Based on these evaluation efforts we believe that several of our programs have been particularly successful including the summer undergraduate and faculty research participation programs and the High School Honors Research Program. Other efforts, including the teacher research participation program and the Science and Engineering Research Semester Program, have only recently been initiated, and it will be several years before we have data sufficient to measure success. The scientific literature tells us, and anecdotal evidence confirms, however, that direct involvement in advanced scientific and technical research is a major influence on career choices and research specialization.

VI. COORDINATION WITH OTHER FEDERAL AGENCIES

The Department of Energy and the National Science Foundation co-chair a formal precollege and undergraduate science education coordinating committee, co-managed by the NSF Assistant Director for Science and Engineering Education, Bassam Shakashiri, and Director of Field Operations Management in the DOE Office of Energy Research, Toni Grayson Joseph. NSF and DOE are collaborating on several precollege science education initiatives. NSF is currently reviewing a proposal from a consortium of six DOE laboratories for a research and instructional program for intermediate school science teachers. This program would be a companion effort to DOE's support for high school science teacher research appointments. NSF has also provided support over the years to precollege teacher programs and instructional materials development efforts at such DOE laboratories as the Lawrence Livermore National Laboratory, Fermilab, the Oak Ridge Associated Universities, Los Alamos National Laboratory and the Brookhaven National Laboratory.

DOE has established a good working partnership with the Department of Education regarding the implementation of Title II of the Education for Economic Security Act, specifically the Mathematics and Science State Grants Program. DOE staff work closely with the State Science Supervisors in each State in their nomination and selection of high school science teachers and students for participation in our laboratory research programs. The teachers selected for the DOE programs may also seek support from their own state science education offices for follow-on activities including in-service training and dissemination of information and materials developed during their research assignment at the DOE laboratory.

Finally, the Department of Education recently provided $322,000 in support of a unique materials sciences technology program created by the DOE Pacific Northwest Laboratory and the Richland Washington School District. These funds will be used to distribute the materials developed in this program to other secondary schools in the Pacific Northwest and to bring science teachers to the Laboratory for training their use.

In addition, there are ongoing periodic meetings at the staff-level among the various science agencies on science education support, so that each agency is aware of the successes of the others and also so that they can avoid any undesired duplication of effort.

VII. DISSEMINATION OF INFORMATION ON DOE SCIENCE EDUCATION PROGRAMS

Good staff contact exists among all the Federal science agencies for the exchange of information on science education programs including model efforts. Periodic meetings are held to update agency staff members on new or proposed science education activities. Even though DOE has been actively involved in science education programs, private industry and the education community at large are not fully aware of that involvement. This is something the Department intends to correct. The last comprehensive published description of the Department's university and science education programs was produced in 1986. A number of new initiatives have begun since then and we will publish a new description of our programs by the end of this year.

We also plan to sponsor a workshop next year in conjunction with NSF to review different models of precollege teacher research participation programs. We expect a number of industrial and university groups to be represented at this meeting along with our own laboratories.

VIII. FUTURE EXPANSION AND DIRECTION OF DOE SCIENCE EDUCATION PROGRAMS

I am pleased with what the Department has accomplished in science education to date. I am convinced we can do far more. This is particularly true with respect to the earlier years of education before young students, especially women and minority students, decide to "drop out" of the science pipeline either consciously or unconsciously. We need to encourage young students to keep their career options open as long as possible and not foreclose on what can be exciting, challenging, and personally rewarding careers in science and technology.

Over the next year I plan to significantly expand the Department's involvement in science education including increasing the number of young students supported in our Prefreshman Engineering Program to 6000 students per year by 1991 and providing additional resources to our National Laboratories for local, regional and national programs at the precollege and university level.

The Department will also become deeply involved in the effort led by the National Academy of Sciences to revitalize precollege mathematics education. A new graduate research fellowship program will be initiated to especially encourage young women and minority students to pursue graduate research. Support will be provided in cooperation with other agencies and private foundations to encourage science and engineering students to become science teachers at the elementary or secondary school level. The Department's role in this effort would be to provide these new teachers with continuing opportunities to participate in ongoing research at one or more DOE laboratories.

Beyond these immediate efforts, I want to work closely with other Cabinet Officers, the President's Science Advisor, the Director of the National Science Foundation and the Administrator of NASA to develop a major national effort involving all of us focused on the middle school years. These are the most critical years for young students in developing career interests. I would also like to see all of us work together, along with our colleagues in the private sector, to see what can be done in those major urban school districts that are so heavily populated with minority students. Each agency brings unique capabilities and resources to focus on the problems and needs in science education. Working together, perhaps under the leadership of a new interagency coordinating council on human resources, we can do far more for the nation than working separately.

IX. SCIENCE EDUCATION CONFERENCE

To this end, I am planning to co-host with Dr. Glenn Seaborg a conference this October 9th and 10th at the Lawrence Hall of Science in Berkeley that will involve the Federal science and education agencies and our private sector counterparts. This will not be a conference to simply review the reasons behind our current crisis in science education -- there have been over 300 studies concluded to date on this subject. Rather, this will be a conference to agree on a coordinated and clearly focused plan of action that can produce specific, measurable results over the next five years.

I will keep this Committee informed as plans for this conference progress, and will also relay to you the conference results.

Conclusion

Mr. Chairman, this concludes the submitted portion of my testimony. I thank you for your invitation to appear before this Committee and look forward to working closely with you on behalf of the Department of Energy in the months and years ahead to further the state of math, science, and engineering education in this country.

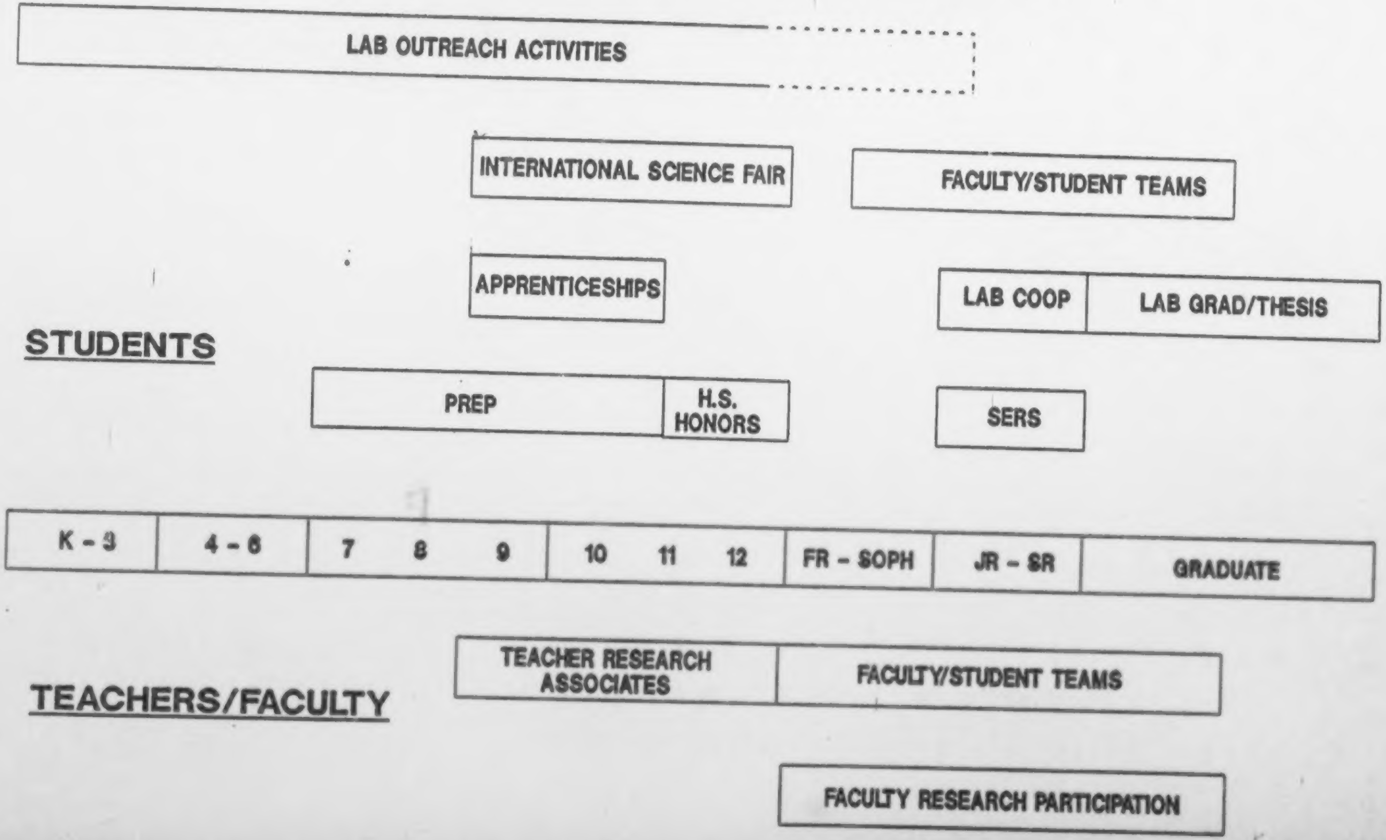
APPENDIX

Department of Energy

Current Precollege and University Science Education Programs

	Participants	
PRECOLLEGE		
- HIGH SCHOOL SCIENCE STUDENT HONORS RESEARCH PROGRAM	374	High School Juniors and Seniors
- TEACHER RESEARCH ASSOCIATES (TRAC) PROGRAM	135-150	High School Teachers
- INTERNATIONAL SCIENCE AND ENGINEERING FAIR AWARDS	10	High School Students/10 Teachers
- PREFRESHMAN ENGINEERING PROGRAM (PREP)	2,000	7th - 10th Graders (underrepresented minorities and women)
- HIGH SCHOOL STUDENT RESEARCH APPRENTICESHIP PROGRAM	130	High School Freshmen and Sophomores (underrepresented minorities and women)
UNDERGRADUATE		
- UNDERGRADUATE STUDENT SUMMER RESEARCH APPOINTMENTS	1,100	Undergraduates
- SCIENCE AND ENGINEERING RESEARCH SEMESTER	300	Juniors and Seniors
- FACULTY/STUDENT TEAMS	50	Undergraduates/Graduates
GRADUATE		
- RESEARCH PARTICIPATION AND THESIS SUPPORT AT DOE LABS	250	Grad Students
- FACULTY/STUDENT TEAMS	50	Undergraduates/Graduates
FACULTY		
- SUMMER AND SABBATICAL RESEARCH AT DOE LABS	300	Faculty
- FACULTY/STUDENT TEAMS	30	Faculty
- WORKSHOPS/INSTITUTES ON ENERGY-RELATED RESEARCH	500	Faculty

OFFICE OF ENERGY RESEARCH
CURRENT SCIENCE EDUCATION PROGRAMS


LAB OUTREACH ACTIVITIES
INTERNATIONAL SCIENCE FAIR
FACULTY/STUDENT TEAMS
APPRENTICESHIPS
LAB COOP
LAB GRAD/THESIS
STUDENTS
PREP
H.S. HONORS
SERS
K - 3
4 - 6
7
8
9
10
11
12
FR - SOPH
JR - SR
GRADUATE
TEACHERS/FACULTY
TEACHER RESEARCH ASSOCIATES
FACULTY/STUDENT TEAMS
FACULTY RESEARCH PARTICIPATION

Secretary WATKINS. As you know, DOE has an important mission in science and engineering education and has many excellent programs already in place. What I would like to do today is focus on not what we are already doing but instead some of the important issues I see facing this country that can only be addressed through a greater understanding of math and science by the broad center of our society, and some of the new objectives needed to help catalyze the nation into a much more focused movement toward a better technological understanding of the world around us.

As we hear so often today, America's leadership in world technology is eroding. There is great competition from many industries for the dwindling number of our best and brightest students in math, science and engineering. Yet these same disciplines seem to be viewed as decreasingly important as career objectives for even this group. Meanwhile, large numbers of our average students, also vital to the readiness of our work force, are increasingly threatened. In many inner-city high schools, this skill shortage is seriously aggravated by dropout rates approaching 50 to 70 percent.

Although America's advantaged students can opt for careers in many professions, they frequently leave the math, science and engineering fields early to pursue what have come to be perceived as more potentially lucrative and perhaps less disciplined academic fields. In fact, America's most disadvantaged students, many of them women and minorities, are frequently never given real encouragement or inspiration to enter these technical skill areas, simply because they have not been helped to become grounded in the technological basics they need to compete and, in some cases, survive in our society.

Meanwhile the march of technology moves forward at an ever more rapid pace, while the traditional approach to science education continues to focus primarily on the top few percent of our students, the ones who in general will make it anyway.

But sadly even that top few percent are not doing all that well either. International testing shows us that our very best upper-level math students do not score as well on mathematics tests as the average Japanese student. In one study of advanced algebra students in 15 countries, the United States placed 14th. The only country we didn't fall behind was Thailand.

In the 1990's some interesting things will be happening in education and in the American work force—some have called it the crisis in math, science, and engineering. And it will have a direct impact on the ability of this nation to even compete, much less to take first place in international markets.

In 1994 we will hit a valley of youngsters coming into the work force as first-time employees, and these young people will be even less prepared to handle the increasingly sophisticated work environments than at any time in our history. America's top 2 percent, the most hardworking and best educated students, will be responsible for developing technology that will dominate the workplace. And in this country the other 98 percent are trying to cope, but are falling behind. That ratio has to change if we are to have any hope of maintaining our competitive edge in this country.

Where will the engineers of the future come from? More and more in this country, they are coming from foreign countries, trained here in our best schools, but many do not stay now. Among our latest crop of Ph.D.'s in engineering, 44 percent were foreign students.

The 1990's will also see a wave of retirements, both in the Federal engineering workforce and in our universities. Many of those who worked in nuclear technology early in its development are now of retirement age. And as American university faculties mature, programs will be cut as it becomes increasingly difficult to recruit new professors. This is the so-called greying of the American university faculties, and it is particularly serious in science and engineering disciplines.

So what does this mean for the rest of society? It means that the growing numbers of less skilled and educated will be forced to live and work around technology and yet may never be able to effectively master it to better their work lives. They will be locked into the hopelessness of an educationally disadvantaged and non-competitive position in the work force. As a consequence, too many will be unable to move upward as the demand for highly skilled few increases and, hence, will continue to fall out of the mainstream of productive and motivated service.

Can we turn this situation around? The answer is yes. Do we know how? The answer is again yes. Will it require an enormous new investment? In my opinion, the answer is no, because much of the needed investment has already been made. We have the technology. We have the teachers—not enough, but we have at least a few to get started—we have the variety of community-based and other organizations in partnership out there who know what works.

And what we need are two things: first, to weld strong consensus that we need to solve this national problem together and, second, to redirect our thinking toward new initiatives, targeting different populations and different goals that will provide the desired skills, health and motivation for the work force by the turn of the century.

This is what I'm here to talk about today. From my experience, working with the Carnegie Corporation of New York, the Education Commission of the States and other educational giants in this nation, I see eight major areas of new thinking that we must address if we are to turn this decline around, and I will summarize briefly these in the interest of time.

Let's talk about new math and science education objectives then. First, increase our emphasis on the middle school years. Those are important decision years, when kids begin to feel that they just can't do math or that science is something only for the smart kids. We are fast learning that upper school may be too late in the adolescent development cycle. To really make a difference, we must begin even younger.

Second, we've got to focus more attention on the average students. We need to build a broader base in our society for technological literacy. We cannot continue to place our top primary emphasis only on the top few percent. We've got to begin a new effort to target that middle strata of students because they, along with women and minorities, will make up almost 80 percent of our emerging work force.

Third, we've got to increase participation of women, minorities and the disabled in science education programs. This nation will not advance in science and mathematics without this large and important segment of society. In the technology race we cannot afford to leave some of our best players on the bench.

We must provide science achievement role models for minority and female youth, and we must make it known throughout the country that physical disabilities are not a hindrance to advanced laboratory work.

Four, we must think of mathematics as the fundamental language of the future. It is one essential base language of the future, and our young people must be fluent in it to compete as future leaders in the world marketplace. And there again we have to start language training early, and I mean long even before middle school.

Five, we in government must increasingly use our world class scientists, engineers and facilities to help motivate and educate America's young and America's teachers. This is an important area in which the Department of Energy can build on existing programs, an area wherein we truly shine, as many of you on this Committee are aware.

We have very little money in our budget for ongoing educational efforts, approximately $12 million. But that does not take into account the value of our equipment or the priceless value of our scientist-teachers. But we can do more and so can many of the approximately 400 other Federal laboratories around the country.

We must also begin to focus more on America's teachers and give them everything they need, including recognition by society, to do their important work well. There is also an important payoff here: for every teacher we train, we reach 150 students, and a new group of 150 students each succeeding year. So this is an area where resources are very well invested.

Six, we need to forge stronger public/private sector partnerships in education. We need to link in a more aggressive way the resources and abilities of the Federal Government to the market-based practicality and inventive- ness of the private sector.

Seventh, we need to encourage greater volunteerism in teaching. Thousands of DOE laboratory scientists serve as volunteers and mentors for high school, undergraduate and graduate students, and we would like to see this excellent example translated down a generation.

When I visited DOE's adopted school here in Washington, Woodrow Wilson High School, a few weeks ago, I spoke to a combined class of physics students, among the brightest in the school and perhaps even in the country. I challenged them to serve as role models for their peers and not be afraid to be good at what they do. I also challenged them to serve as mentors for younger students, tutors who could provide both learning and encouragement.

In our colleges I would like to see this important concept carried even further. There is a growing movement to incorporate youth community service into college curricula and make it a requirement for graduation. I believe this is now in over 100 colleges in the nation.

This is something with which I strongly concur. It goes hand-in-hand with what the President is doing with the Office of National Service in his YES, Youth Engage in Service to America initiative, and it would provide much- needed education resources and role models for our younger students.

Eighth and last, we must take advantage of what we already know works and run with it. In large bureaucracies, because our attention is usually drawn to the big things that are broken, it is easy to lose sight of the small quiet programs that work, and yet it is those very programs that can have a big impact on society. We need more interdepart-mental communication and cooperative action. Throughout government, we need to dig down into our systems and pull up examples of excellence and highlight them for ourselves and for the public. We need to build confidence that we can do this job better than anyone and that this is an important mission we can all be proud of.

These, then, are eight priorities I believe we must establish to confront what we are all beginning to recognize as a genuine mathematics and science education crisis in the nation.

At Department of Energy, we have the expertise, we have the labs, we have the spirit and we have enough dollars for the moment. We want to utilize resources already in place, build upon this base and move forward. We don't have to construct or pay for a multi-billion dollar laboratory system; it's already there. We don't have to train scientific expertise; it's already there.

What's been missing in the past has been strong leadership and continuing recognition from the top that this is not just important, but is key to our ability to carry out the nation's technical work.

Obviously, DOE is but one bridge between our relative state of scientific ignorance and a competitive world. But maybe we can set a more visible and creative example for industry and other Federal labs than in the past and help gain momentum across the nation as a whole. Anyway, we're going to try harder.

Mr. Chairman, I would like to take this opportunity to announce a conference that Department of Energy is planning to hold in conjunction with Dr. Glenn Seaborg at the Lawrence Hall of Science in Berkeley next October 9th and 10th. There, with the help and participation of the Department of Education, NASA, Department of Defense, NIH and others in Federal education leadership positions, we hope to come to grips with many of these initiatives and leave the conference with some concrete proposals that we can then immediately begin to implement within our own departments.

There have been well over 300 studies on the subject of education reform, and the time for research and discussion is now past. It's time to put our words and our best educational effort to work for America's youth and America's future.

Mr. Chairman, as plans for this conference progress, I will keep you and this Committee informed, and will submit the final report of the conference to this Committee as well.

That concludes my prepared remarks. And I am grateful for the interest in the Department of Energy's science education programs, and I am proud to present these words here to you today and would be happy to answer any questions.

[The prepared statement of Secretary Watkins follows:]

Department of Energy
Washington, DC 20585

REMARKS OF

THE HONORABLE JAMES D. WATKINS
ADMIRAL, U.S. NAVY (RETIRED)
SECRETARY OF ENERGY

AT A HEARING ON

MATHEMATICS AND SCIENCE EDUCATION

BEFORE

THE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

MAY 24, 1989

2318 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, D.C.

MR. CHAIRMAN, MEMBERS OF THE COMMITTEE, I AM GRATEFUL FOR THE OPPORTUNITY TO BE WITH YOU TODAY TO TALK ABOUT A SUBJECT THAT IS VERY IMPORTANT TO ME AS SECRETARY OF ENERGY, BUT ALSO TO ME PERSONALLY -- THE EDUCATION OF AMERICA'S YOUNG PEOPLE. WITH ME TODAY ARE TWO MEMBERS OF MY STAFF, MS. TONI GRAYSON JOSEPH, AND MR. RICHARD STEPHENS, WHO SUPERVISE DOE'S EDUCATION PROGRAMS.

I KNOW MANY MEMBERS OF THIS COMMITTEE ARE FULLY FAMILIAR WITH THE IMPRESSIVE WORK DOE IS DOING IN SCIENCE AND ENGINEERING EDUCATION -- SEVERAL OF YOU HAVE DOE LABS IN YOUR DISTRICTS, AND KNOW THE VALUE OF OUR "HANDS-ON RESEARCH" SUPPORT OF SCIENCE EDUCATION. MR. CHAIRMAN, I HAVE PREPARED A REPORT ON OUR PROGRAMS, WHICH HAS BEEN SUBMITTED TO THE COMMITTEE, AND I REQUEST THAT THIS REPORT BE INCLUDED IN THE RECORD AS PART OF MY TESTIMONY.

AS YOU KNOW, DOE HAS AN IMPORTANT MISSION IN SCIENCE AND ENGINEERING EDUCATION, AND HAS MANY EXCELLENT PROGRAMS ALREADY IN PLACE. WHAT I WOULD LIKE TO FOCUS ON TODAY IS NOT WHAT WE ARE ALREADY DOING, BUT, INSTEAD SOME OF THE IMPORTANT ISSUES I SEE FACING THIS COUNTRY THAT CAN ONLY BE ADDRESSED THROUGH A GREATER UNDERSTANDING OF MATH AND SCIENCE BY THE BROAD CENTER OF OUR SOCIETY, AND SOME OF THE NEW OBJECTIVES NEEDED TO HELP CATALYZE THE NATION INTO A MUCH MORE FOCUSED MOVEMENT TOWARD A BETTER TECHNOLOGICAL UNDER- STANDING OF THE WORLD AROUND US.

AS WE HEAR SO OFTEN TODAY, AMERICA'S LEADERSHIP IN WORLD TECHNOLOGY IS ERODING. THERE IS GREAT COMPETITION FROM MANY INDUSTRIES FOR THE DWINDLING NUMBERS OF OUR BEST AND BRIGHTEST STUDENTS IN MATH, SCIENCE AND ENGINEERING. YET THESE SAME DISCIPLINES SEEM TO BE VIEWED AS DECREASINGLY IMPORTANT AS CAREER OBJECTIVES FOR EVEN THIS GROUP. MEANWHILE, LARGE NUMBERS OF OUR AVERAGE STUDENTS, ALSO VITAL TO THE READINESS OF OUR WORKFORCE, ARE INCREASINGLY THREATENED. IN MANY INNER CITY HIGH SCHOOLS, THIS SKILL SHORTAGE IS SERIOUSLY AGGRAVATED BY DROP OUT RATES APPROACHING 50-70 PERCENT.

ALTHOUGH AMERICA'S ADVANTAGED STUDENTS CAN OPT FOR CAREERS IN MANY PROFESSIONS, THEY FREQUENTLY LEAVE THE MATH, SCIENCE AND ENGINEERING FIELDS TO PURSUE WHAT HAVE COME TO BE PERCEIVED AS MORE POTENTIALLY LUCRATIVE AND, PERHAPS, LESS DISCIPLINED ACADEMIC FIELDS. IN FACT, AMERICA'S MOST DISADVANTAGED STUDENTS, MANY OF THEM WOMEN AND MINORITIES, ARE FREQUENTLY NEVER GIVEN REAL ENCOURAGEMENT OR INSPIRATION TO ENTER THESE TECHNICAL SKILL AREAS -- SIMPLY BECAUSE THEY HAVE NOT BEEN HELPED TO BECOME GROUNDED IN THE TECHNOLOGICAL BASICS THEY NEED TO COMPETE -- AND, IN SOME CASES, SURVIVE -- IN OUR SOCIETY.

MEANWHILE, THE MARCH OF TECHNOLOGY MOVES FORWARD AT AN EVER MORE RAPID PACE, WHILE THE TRADITIONAL APPROACH TO SCIENCE EDUCATION CONTINUES TO FOCUS PRIMARILY ON THE TOP 10 PERCENT OF

OUR STUDENTS -- THE ONES WHO, IN GENERAL, WILL MAKE IT ANYWAY.

BUT, SADLY, EVEN THAT TOP 10 PERCENT ARE NOT DOING ALL THAT WELL EITHER. INTERNATIONAL TESTING SHOWS US THAT OUR VERY BEST UPPER LEVEL MATH STUDENTS DO NOT SCORE AS WELL ON MATHEMATICS TESTS AS THE AVERAGE JAPANESE STUDENT.

IN ONE STUDY OF ADVANCED ALGEBRA STUDENTS IN 15 COUNTRIES, THE UNITED STATES PLACED 14TH -- THE ONLY COUNTRY WE DIDN'T FALL BEHIND WAS THAILAND.

IN THE 1990'S SOME INTERESTING THINGS WILL BE HAPPENING IN EDUCATION AND IN THE AMERICAN WORKFORCE -- SOME HAVE CALLED IT THE CRISIS IN MATH, SCIENCE AND ENGINEERING -- AND IT WILL HAVE A DIRECT IMPACT ON THE ABILITY OF THIS NATION TO EVEN COMPETE, MUCH LESS TO TAKE FIRST PLACE IN INTERNATIONAL MARKETS.

IN 1994 WE WILL HIT A "VALLEY" OF YOUNGSTERS COMING INTO THE WORKFORCE AS FIRST TIME EMPLOYEES, AND THESE YOUNG PEOPLE WILL BE EVEN LESS PREPARED TO HANDLE THE INCREASINGLY SOPHISTICATED WORK ENVIRONMENTS THAN AT ANY TIME IN OUR HISTORY. AMERICA'S TOP 2 PERCENT -- THE MOST HARDWORKING AND BEST EDUCATED STUDENTS -- WILL BE RESPONSIBLE FOR DEVELOPING TECHNOLOGY THAT WILL DOMINATE THE WORKPLACE -- AND IN THIS COUNTRY, THE OTHER 98 PERCENT ARE TRYING TO COPE -- BUT ARE FALLING BEHIND.

THAT RATIO HAS TO CHANGE IF WE ARE TO HAVE ANY HOPE OF MAINTAINING OUR COMPETITIVE EDGE IN THIS COUNTRY. WHERE WILL THE ENGINEERS OF THE FUTURE COME FROM? MORE AND MORE IN THIS COUNTRY, THEY ARE COMING FROM FOREIGN COUNTRIES -- TRAINED HERE IN OUR BEST SCHOOLS -- BUT MANY DO NOT STAY. AMONG OUR LATEST CROP OF PH.D.s IN ENGINEERING, 44 PERCENT WERE FOREIGN STUDENTS.

THE 1990'S WILL ALSO SEE A WAVE OF RETIREMENTS, BOTH IN THE FEDERAL ENGINEERING WORKPLACE, AND IN OUR UNIVERSITIES. MANY OF THOSE WHO WORKED IN NUCLEAR TECHNOLOGY EARLY IN ITS DEVELOPMENT ARE NOW OF RETIREMENT AGE, AND AS AMERICAN UNIVERSITY FACULTIES MATURE, PROGRAMS MAY BE CUT AS IT BECOMES INCREASINGLY DIFFICULT TO RECRUIT NEW PROFESSORS. THIS IS THE SO-CALLED "GREYING OF AMERICAN UNIVERSITY FACULTIES," AND IT IS PARTICULARLY SERIOUS IN SCIENTIFIC AND ENGINEERING DISCIPLINES.

WHAT DOES THIS MEAN FOR THE REST OF OUR SOCIETY? IT MEANS THAT THE GROWING NUMBERS OF LESS SKILLED AND EDUCATED WILL BE FORCED TO LIVE AND WORK AROUND TECHNOLOGY, AND YET, MAY NEVER BE ABLE TO EFFECTIVELY MASTER IT TO BETTER THEIR WORK LIVES. THEY WILL BE LOCKED INTO THE HOPELESSNESS OF AN EDUCATIONALLY DISADVANTAGED AND NON-COMPETITIVE POSITION IN THE WORKFORCE. AS A CONSEQUENCE, TOO MANY WILL BE UNABLE TO MOVE UPWARD AS THE DEMAND FOR THE HIGHLY SKILLED FEW INCREASES AND, HENCE, WILL CONTINUE TO FALL OUT OF THE MAINSTREAM OF PRODUCTIVE AND MOTIVATED SERVICE.

CAN WE TURN THIS AROUND? THE ANSWER IS YES. DO WE KNOW HOW? THE ANSWER IS AGAIN, YES. WILL IT REQUIRE AN ENORMOUS NEW INVESTMENT? THE ANSWER IS NO, BECAUSE MUCH OF THE NEEDED INVESTMENT HAS ALREADY BEEN MADE. WE HAVE THE TECHNOLOGY, WE HAVE THE TEACHERS AND WE HAVE THE VARIETY OF COMMUNITY-BASED AND OTHER ORGANIZATIONS IN PARTNERSHIP OUT THERE WHO KNOW WHAT WORKS. WHAT WE NEED ARE TWO THINGS: FIRST, TO WELD STRONG CONSENSUS THAT WE NEED TO SOLVE THIS NATIONAL PROBLEM TOGETHER; AND SECOND, TO REDIRECT OUR THINKING TOWARD NEW INITIATIVES, TARGETING DIFFERENT POPULATIONS AND DIFFERENT GOALS THAT WILL PROVIDE THE DESIRED SKILLS, HEALTH, AND MOTIVATION FOR THE WORKFORCE BY THE TURN OF THE CENTURY.

THIS IS WHAT I AM HERE TO TALK ABOUT WITH YOU TODAY. FROM MY EXPERIENCE WORKING WITH THE CARNEGIE CORPORATION OF NEW YORK, THE EDUCATION COMMISSION OF THE STATES, AND OTHER EDUCATIONAL GIANTS IN THIS NATION, I SEE EIGHT MAJOR AREAS OF NEW THINKING THAT WE MUST ADDRESS IF WE ARE TO TURN THIS DECLINE AROUND.

NEW MATH AND SCIENCE EDUCATION OBJECTIVES

(1) INCREASE OUR EMPHASIS ON MIDDLE SCHOOL YEARS. THE SCIENTISTS OF THE 21ST CENTURY ARE IN THOSE MIDDLE GRADES NOW. THOSE ARE IMPORTANT DECISION YEARS -- WHEN KIDS BEGIN TO FEEL THAT THEY JUST CAN'T DO MATH, OR THAT SCIENCE IS SOMETHING ONLY FOR "SMART KIDS." OUR NEXT BIG WAVE OF STUDENTS IS NOW IN THE THIRD GRADE, AND WE NEED TO HAVE PROGRAMS IN PLACE FOR THEM SOON. WE MAY BE DOING OUR BEST JOB WITH OUR OLDER STUDENTS -- BUT THEY CONTINUE TO FALL BEHIND THEIR INTERNATIONAL COUNTERPARTS. WE NEED TO DO A BETTER JOB WITH THEM FOR SURE, BUT WE ARE FAST LEARNING THAT UPPER SCHOOL MAY BE TOO LATE IN THE ADOLESCENT DEVELOPMENT CYCLE. TO REALLY MAKE A DIFFERENCE, WE MUST BEGIN EVEN YOUNGER.

(2) FOCUS MORE ATTENTION ON "AVERAGE" STUDENTS. WE NEED TO BUILD A BROADER BASE IN OUR SOCIETY FOR TECHNICAL LITERACY. WE CANNOT CONTINUE TO PLACE OUR PRIMARY EMPHASIS ONLY ON THE TOP FEW PERCENT. WE MUST BEGIN A NEW EFFORT TO TARGET THAT MIDDLE STRATA OF STUDENTS BECAUSE THEY, ALONG WITH WOMEN AND MINORITIES, WILL MAKE UP ALMOST 80 PERCENT OF OUR EMERGING WORKFORCE. WE MUST EQUIP THEM WITH BASIC SKILLS, AND AT THE VERY LEAST A MINIMUM LEVEL OF SCIENCE KNOWLEDGE SUFFICIENT TO LET THEM UNDERSTAND, THROUGH A SOLID GROUNDING FROM A CONTINUUM OF LIFE SCIENCES IN SCHOOL, INCLUDING THEIR OWN HUMAN BIOLOGY, HOW THINGS WORK IN THE WORLD AROUND THEM. WITH THIS KNOWLEDGE THEY CAN HAVE SOME HOPE OF BEING FULL PARTICIPANTS IN A SOCIETY THAT IS INCREASINGLY COMPLEX TECHNOLOGICALLY; ONE THAT RAISES SUCH FEAR AND APPREHENSION IN SO MANY THAT SELF-CONFIDENCE AND SELF-ESTEEM ARE LOST.

(3) INCREASE PARTICIPATION OF WOMEN, MINORITIES, AND THE DISABLED IN SCIENCE EDUCATION PROGRAMS. IF WE ALL AGREE THAT IT IS IMPERATIVE TO EXPAND THE OPPORTUNITIES FOR WOMEN, MINORITIES, AND THE DISABLED TO PREPARE FOR CAREERS IN MATHEMATICS, SCIENCE, AND ENGINEERING, THEN OUR EDUCATIONAL FOCUS MUST SHIFT TO PROVIDE ADEQUATE OPPORTUNITIES FOR PREPARATORY TRAINING NECESSARY TO THESE FIELDS.

THIS NATION WILL NOT ADVANCE IN SCIENCE AND MATHEMATICS WITHOUT THIS LARGE AND IMPORTANT SEGMENT OF SOCIETY -- IN THE TECHNOLOGY RACE, WE CANNOT AFFORD TO LEAVE SOME OF OUR BEST PLAYERS ON THE BENCH.

THE HISTORICALLY BLACK COLLEGES AND UNIVERSITIES PROGRAM PROVIDES A CONDUIT TO MINORITY STUDENTS AT THE COLLEGE LEVEL, BUT WE NEED TO BECOME MUCH MORE ACTIVE IN OUR INNER CITIES WITH MUCH YOUNGER CHILDREN -- WELL BEFORE COLLEGE, OR EVEN HIGH SCHOOL. WE MUST PROVIDE SCIENCE ACHIEVEMENT ROLE MODELS FOR MINORITY AND FEMALE YOUTH, AND WE MUST MAKE IT KNOWN THROUGHOUT THE COUNTRY THAT PHYSICAL DISABILITIES ARE NOT A HINDRANCE TO ADVANCED LABORATORY WORK.

(4) WE MUST THINK OF MATHEMATICS AS THE FUNDAMENTAL LANGUAGE OF THE FUTURE. IN THE LATE 1950'S, AFTER SPUTNIK, AMERICA BEGAN A NEW EDUCATION PUSH TO PROVIDE ITS STUDENTS WITH FOREIGN LANGUAGES SO THAT THEY COULD TAKE THEIR PLACE AS CITIZENS OF THE WORLD. TODAY WE HAVE A GREATER NEED TO UNDERSTAND AN EVEN MORE FUNDAMENTAL LANGUAGE -- MATHEMATICS. IF TAUGHT EARLY ENOUGH AND WELL, IT CAN BE LEARNED -- JUST AS ANY NEW LANGUAGE -- BY ALL PEOPLE IN SOCIETY. IT IS ONE ESSENTIAL BASE LANGUAGE OF THE FUTURE -- FOR SCIENCE, FOR ENGINEERING, FOR BUSINESS, AND EVEN FOR MUSIC AND OTHER ARTS -- AND OUR YOUNG PEOPLE MUST BE FLUENT IN IT TO COMPETE AS FUTURE LEADERS IN THE WORLD MARKETPLACE.

(5) WE IN GOVERNMENT MUST INCREASINGLY USE OUR WORLD CLASS SCIENTISTS, ENGINEERS, AND FACILITIES TO HELP MOTIVATE AND EDUCATE AMERICA'S YOUNG -- AND AMERICA'S TEACHERS. THIS IS AN AREA IN WHICH THE DEPARTMENT OF ENERGY CAN BUILD ON EXISTING PROGRAMS -- AN AREA WHEREIN WE TRULY SHINE, AS MANY OF YOU ON THIS COMMITTEE ARE AWARE. WE HAVE VERY LITTLE MONEY IN OUR BUDGET FOR ONGOING EDUCATIONAL EFFORTS -- APPROXIMATELY $12 MILLION DOLLARS -- BUT THAT DOES NOT TAKE INTO ACCOUNT THE VALUE OF OUR EQUIPMENT, OR THE PRICELESS VALUE OF OUR SCIENTIST-TEACHERS. WE ARE DOING GREAT THINGS, AND WE ARE JUSTIFIABLY PROUD -- BUT WE CAN DO MORE, AND SO CAN MANY OF THE APPROXIMATELY 400 OTHER FEDERAL LABORATORIES AROUND THE COUNTRY.

WE MUST ALSO BEGIN TO FOCUS MORE ON AMERICA'S TEACHERS, AND GIVE THEM EVERYTHING THEY NEED -- INCLUDING RECOGNITION BY SOCIETY -- TO DO THEIR IMPORTANT WORK WELL. WE CAN, AND DO, OFFER MANY TEACHERS THE OPPORTUNITY TO WORK WITH US AT DOE LABS DURING THE SUMMERS, AND THEY RETURN TO THEIR CLASSROOMS EXCITED

ABOUT SCIENCE, CHALLENGED, AND READY TO CHALLENGE THEIR STUDENTS. THERE'S ALSO AN IMPORTANT PAYOFF HERE -- FOR EVERY TEACHER WE TRAIN, WE REACH 150 STUDENTS -- AND A NEW GROUP OF 150 STUDENTS EACH SUCCEEDING YEAR. SO THIS IS AN AREA WHERE RESOURCES ARE VERY WELL INVESTED.

(6) **FORGE STRONGER PUBLIC/PRIVATE SECTOR PARTNERSHIPS IN EDUCATION**. WE NEED TO LINK IN A MORE AGGRESSIVE WAY THE RESOURCES AND ABILITIES OF THE FEDERAL GOVERNMENT TO THE MARKET BASED PRACTICALITY AND INVENTIVENESS OF THE PRIVATE SECTOR. WE AT DOE CAN -- AND DO -- WORK WITH OUR CONTRACTORS TO ENCOURAGE THIS TYPE OF PARTICIPATION. ONE PRIVATE SECTOR GROUP, NACME -- THE NATIONAL ACTION COUNCIL FOR MINORITY ENGINEERS -- HAS FORGED LINKAGES WITH MAJOR CORPORATIONS TO PROVIDE MENTORING AND EMPLOYMENT. THIS FORWARD-THINKING GROUP, BY THE WAY, HAS TARGETED AS THEIR ENGINEERS OF THE FUTURE, CHILDREN WHO ARE NOW IN THE THIRD GRADE.

(7) **ENCOURAGE GREATER VOLUNTEERISM IN TEACHING.** In our laboratories: IN ADDITION TO THE "HANDS-ON" RESEARCH PROJECTS FOR STUDENTS AND TEACHERS IN DOE LABS, THE DEPARTMENT UNDERTAKES MAJOR VOLUNTEER WORK -- SCIENTISTS TEACHING ON SATURDAYS, OR SPENDING THEIR OWN TIME WITH HIGH SCHOOL STUDENTS DURING TWO WEEK RESIDENCY PROGRAMS. THOUSANDS OF DOE LABORATORY SCIENTISTS SERVE AS VOLUNTEERS AND MENTORS FOR HIGH SCHOOL, UNDERGRADUATE AND GRADUATE STUDENTS, AND WE WOULD LIKE TO SEE THIS EXCELLENT EXAMPLE TRANSLATED DOWN A GENERATION.

In our high schools: WHEN I VISITED DOE'S ADOPTED SCHOOL, WOODROW WILSON HIGH SCHOOL HERE IN THE DISTRICT, A FEW WEEKS AGO, I SPOKE TO A COMBINED CLASS OF PHYSICS STUDENTS, AMONG THE BRIGHTEST IN THE SCHOOL, MAYBE EVEN THE COUNTRY. I CHALLENGED THEM TO SERVE AS ROLE MODELS FOR THEIR PEERS AND NOT BE AFRAID TO BE GOOD AT WHAT THEY DO. I ALSO CHALLENGED THEM TO SERVE AS MENTORS FOR YOUNGER STUDENTS -- TUTORS WHO COULD PROVIDE BOTH LEARNING AND ENCOURAGEMENT. EDUCATION RESEARCHERS HAVE CONCLUDED THAT SOME OF THE BEST LEARNING TAKES PLACE THIS WAY -BOTH FOR THE STUDENT AND FOR THE MENTOR.

In our colleges: I WOULD LIKE TO SEE THIS IMPORTANT CONCEPT CARRIED EVEN FURTHER -- INTO OUR COLLEGES. THERE IS A GROWING MOVEMENT TO INCORPORATE YOUTH COMMUNITY SERVICE INTO COLLEGE CURRICULA AND MAKE IT A REQUIREMENT FOR GRADUATION. THIS IS SOMETHING WITH WHICH I STRONGLY CONCUR. IT GOES HAND IN HAND WITH WHAT THE PRESIDENT IS DOING WITH THE OFFICE OF NATIONAL SERVICE, AND IT WOULD PROVIDE MUCH NEEDED EDUCATION RESOURCES AND ROLE MODELS FOR OUR YOUNGER STUDENTS.

(8) AND LAST, **WE MUST TAKE ADVANTAGE OF WHAT WE ALREADY KNOW WORKS -- AND RUN WITH IT**. WE ALL HAVE TO PAY GREATER ATTENTION TO THE GOOD WORK GOING ON AROUND US, AND NOT "REINVENT THE WHEEL." IN LARGE BUREAUCRACIES, BECAUSE OUR ATTENTION IS

USUALLY DRAWN TO THE BIG THINGS THAT ARE BROKEN, IT IS EASY TO LOSE SIGHT OF THE SMALL QUIET PROGRAMS THAT WORK. AND YET IT IS THOSE VERY PROGRAMS THAT CAN HAVE A BIG IMPACT ON SOCIETY. WE NEED MORE INTERDEPARTMENTAL COMMUNICATION AND COOPERATIVE ACTION. THROUGHOUT GOVERNMENT, WE NEED TO DIG DOWN INTO OUR SYSTEMS, AND PULL UP EXAMPLES OF EXCELLENCE, AND HIGHLIGHT THEM FOR OURSELVES AND FOR THE PUBLIC. WE NEED TO BUILD CONFIDENCE THAT WE CAN DO THIS JOB BETTER THAN ANYONE, AND THAT THIS IS AN IMPORTANT MISSION WE CAN ALL BE PROUD OF.

FOR EXAMPLE, I MET WITH ALL OF THE DIRECTORS OF OUR NATIONAL LABORATORIES LAST WEEK AND CHALLENGED THEM TO COME BACK TO ME WITH INNOVATIVE PROGRAMS THAT CAN REACH OUR INNER CITIES. MANY OF THEM ARE ALREADY DOING EXCELLENT WORK -- FERMI AND ARGONNE, TO NAME JUST TWO. BUT MY GOAL IS FOR THEM TO BE MODELS OF EXCELLENCE TO THE REST OF THE SYSTEM, AND FOR THEM TO WORK TOGETHER TO TARGET CHICAGO'S INNER CITY KIDS, THE WAY WE NEED LIVERMORE AND BERKELEY TO TARGET OAKLAND OR RICHMOND.

ANOTHER EXAMPLE: I RECENTLY ASKED ALL OF OUR PROGRAM DIRECTORS TO NAME TWO EMPLOYEES WHO WERE OUTSTANDING IN THEIR VOLUNTEER EFFORTS. ONE OF THE NOMINEES WAS AN ENGINEER IN ALBUQUERQUE WHO HAS BEEN ACTIVE IN ELEMENTARY, JUNIOR HIGH AND HIGH SCHOOL CLASSROOMS THROUGHOUT HIS STATE, PRESENTING A "ONE MAN SHOW" THAT STRESSES THE IMPORTANCE OF A GOOD EDUCATION IN MATH, SCIENCE, AND ENGLISH.

THESE, THEN, ARE EIGHT PRIORITIES I BELIEVE WE MUST ESTABLISH TO CONFRONT WHAT WE ARE ALL BEGINNING TO RECOGNIZE AS A GENUINE MATHEMATICS AND SCIENCE EDUCATION CRISIS IN THIS NATION.

AT DOE, WE HAVE THE EXPERTISE, WE HAVE THE LABS, WE HAVE THE SPIRIT, AND WE HAVE ENOUGH DOLLARS FOR THE MOMENT. WE WANT TO UTILIZE RESOURCES ALREADY IN PLACE, BUILD UPON THIS BASE, AND MOVE FORWARD. WE DON'T HAVE TO CONSTRUCT OR PAY FOR A MULTI-BILLION DOLLAR LABORATORY SYSTEM -- IT'S ALREADY THERE. WE DON'T HAVE TO TRAIN SCIENTIFIC EXPERTISE -- WE ALREADY HAVE THE BEST IN THE WORLD.

WHAT'S BEEN MISSING IN THE PAST HAS BEEN STRONG LEADERSHIP AND CONTINUING RECOGNITION FROM THE TOP THAT THIS IS NOT JUST IMPORTANT, BUT IT IS KEY TO OUR ABILITY TO CARRY OUT THE NATION'S TECHNICAL WORK. NOW MY DEPARTMENT HAS ITS MARCHING ORDERS, AND OUR PEOPLE WILL PRODUCE -- BECAUSE THEY'RE GOOD, AND BECAUSE EDUCATION IS ONE OF THE THINGS THEY LIKE BEST ABOUT THEIR WORK.

OBVIOUSLY, DOE IS BUT ONE BRIDGE BETWEEN OUR RELATIVE STATE OF SCIENTIFIC IGNORANCE AND A COMPETITIVE WORLD. BUT MAYBE WE CAN SET A MORE VISIBLE AND CREATIVE EXAMPLE FOR INDUSTRY AND OTHER FEDERAL LABS THAN IN THE PAST, AND HELP GAIN MOMENTUM ACROSS THE NATION AS A WHOLE. WE'RE GOING TO TRY HARDER, ANYWAY.

DOE SCIENCE EDUCATION CONFERENCE

MR. CHAIRMAN, I WOULD LIKE TO TAKE THIS OPPORTUNITY TO ANNOUNCE A CONFERENCE THAT DOE IS PLANNING IN CONJUNCTION WITH DR. GLENN SEABORG AND THE LAWRENCE HALL OF SCIENCE IN BERKELEY, NEXT OCTOBER 9 AND 10. THERE, WITH THE HELP AND PARTICIPATION OF THE DEPARTMENT OF EDUCATION, NASA, THE DEPARTMENT OF DEFENSE, NIH, AND OTHERS IN FEDERAL EDUCATION LEADERSHIP POSITIONS, WE HOPE TO COME TO GRIPS WITH MANY OF THESE INITIATIVES, AND LEAVE THE CONFERENCE WITH SOME CONCRETE PROPOSALS THAT WE CAN THEN IMMEDIATELY BEGIN TO IMPLEMENT WITHIN OUR OWN DEPARTMENTS.

THERE HAVE BEEN WELL OVER 300 STUDIES ON THE SUBJECT OF EDUCATION REFORM -- THE TIME FOR RESEARCH AND DISCUSSION IS NOW PAST. IT'S TIME TO PUT OUR WORDS AND OUR BEST EDUCATIONAL EFFORT TO WORK FOR AMERICA'S YOUTH AND AMERICA'S FUTURE.

MR. CHAIRMAN, AS PLANS FOR THIS CONFERENCE PROGRESS, I WILL KEEP YOU AND THIS COMMITTEE INFORMED, AND WILL SUBMIT THE FINAL REPORT OF THE CONFERENCE TO THIS COMMITTEE AS WELL.

CONCLUSION

MR. CHAIRMAN, AND MEMBERS OF THE COMMITTEE, THAT CONCLUDES MY PREPARED REMARKS. I AM GRATEFUL FOR YOUR INTEREST IN THE DEPARTMENT OF ENERGY'S SCIENCE EDUCATION PROGRAMS, WHICH I AM PROUD TO REPRESENT HERE TODAY, AND I WILL BE HAPPY TO ANSWER ANY QUESTIONS.

The **Chairman**. Thank you very much, Mr. Secretary, for a splendid statement.

The Chair recognizes the distinguished gentleman from California, Mr. Brown, for any questions.

Mr. **Brown**. Thank you very much, Mr. Chairman. I would like to join with you in commending Admiral Watkins' statement, and I think that this represents about as comprehensive approach to using the resources of his Department to further math and science education as I've seen.

Let me just ask one question: I noted in your point five that you recommend using our scientists, engineers and facilities to motivate and educate America's young; and, in your supplementary statement, you point out many of the ways that you're doing that.

You seem to be doing more there than many of our world class universities are doing in terms of outreach into the community, to the lower schools and so forth. Can you suggest how we might encourage other institutions, including our first rank universities, to undertake this partnership with their local schools, the elementary through the high schools, and expand their impact—which I'm not denigrating in any way, it's great, but as you pointed out we need to permeate our society with this kind of knowledge, attitude, inspiration from our outstanding people.

Secretary **Watkins**. One of the things I learned, Mr. Congressman, working intensely in the past eight years in the whole field of education and as we move around the country and listen to people—and certainly enhanced by my experience on the AIDS Commission—we find the one real way to motivate youngsters is by peer mentoring and peer association with bright young kids up above them that they can see and reach and touch.

And I think the whole concept of the campus compact which is now moving into over 100 colleges where youth community service is now a part of academic life in those colleges for graduation. It is incumbent on the math, science, and engineering students to reach down into the high schools that feed them and help them motivate more youngsters.

Where this has been done, math, science, and engineering motivation has increased by a factor of three. I know that's the case in New York at the Polytechnic Institute there. And so these are the kinds of things we need to start doing.

And then in the high schools, we need to motivate, as I pointed out in my address here today, those bright youngsters in math, science and engineering to reach down and help their peers, help tutor and mentor them, along with the adults. It isn't good enough just for the adults to pontificate about this. We have to really gain a new concept of involving ourselves and the youngsters in this work.

Then I would hope the junior high schools would reach down into the elementary schools that feed them, and then we, in the preschool area, start preparing these youngsters for entry into school at all.

I mean where is Head Start today and all that kind of thing? We need to get their health up, we need to identify those slow learners, the ones with cognitive development problems, early and give them a chance to survive.

So this whole process has to be a continuum. It cannot start at any one point, and it doesn't have a simple fix. It won't work with a computer system, for example. We have to start from scratch on this thing and go back to very basic things, starting with the very earliest motivation of these youngsters to go through this process.

We are merely in this trying to pick up the pieces at the middle school level, which is the 10- to 15-year olds, and get our people working with community-based organizations and with those involved with youth community service, particularly universities.

I want to go to the University of Chicago and get them to help a great deal with their students, not just their faculty, their students to reach down at the Fermi lab and help them out and provide the motivation and the hand- holding that's necessary to get those kids for summer internships, for weekends, for the tutoring program to take advantage of all of our facilities and all that kind of thing.

So really I think what we're talking about here is the whole concept of involving American young people in themselves. I think that's a resource we haven't tapped in this country for motivation, and I think it's time to start.

Mr. Brown. I agree with you, Admiral.

I would just like to make one additional point, and I hope I won't be seen as self-serving. But the Congress has frequently spoken on the need to improve education.

Yesterday I spent an hour in an elementary school reading with elementary school students and making a few pitches for interest in science and math. The Congress voted a resolution denoting 1989 as the year to encourage reading.

What I'd like to suggest is that even Congressmen—most of whom can read—

[Laughter.]

—ought to spend an hour a month in their elementary schools reading with these kids instead of just voting on a resolution. Most of the members of Congress, I'm sure, don't remember that they voted for this resolution. And not only should Congressmen do it but everyone else should get involved.

And this is the message I'm getting from you. That in your labs and in the Department, you're getting involved and you're trying to set the pace for others getting involved. And we ought to be following that kind of a pace.

Thank you.

The Chairman. The Chair recognizes the distinguished gentleman from New York, Mr. Scheuer.

Mr. Scheuer. Thank you, Mr. Chairman.

Admiral Watkins, I think it's extraordinary that you, as a military man now heading up the Department of Energy, should advert in your testimony to the Head Start program. It takes an extraordinary breadth of vision to equate a vigorous and far-reaching Head Start program with a trained and competent work force, especially in the fields of science, math and engineering. Very few Cabinet secretaries would do that.

I'd like you to elaborate on it because many of us in Congress are concerned that the Head Start program may be the last best chance—not the first best chance, but the last best chance to save educationally-disadvantaged kids and prepare them for educational success.

For many of these two-thirds or three-quarters of the educationally-disadvantaged kids that you refer to in the inner-cities, for many of them, Head Start is the last chance we'll get to help them make it by the time they hit the formal schoolhouse doors. The ones that don't get it are primarily—are almost overwhelmingly consigned to education failure, and they are lost to the field of science, math and engineering.

There may be a Fermi; there may be an Einstein out there. Remember, Einstein did very poorly in his school studies. His genius didn't blossom until long after he got out of school.

We are currently, after 24 years of Head Start—you mentioned someplace in here that we ought to get going with our successes and build on our successes, reach down for the program that are successful. We need to dig down in our systems and pull up examples of excellence and highlight them for ourselves and for the public.

No success, no program of excellence exceeds Head Start in its promise. Yet after 24 years of demonstrated success, about 16 percent of the educationally-disadvantaged kids who are at risk get the benefit of Head Start.

Now I'm a Head Start kid. Kids from middle-class and upper middle-class homes have been getting head start for a century. We called it pre-kindergarten in 1923 when I went there.

[Laughter.]

1923, count them.

But kids who need it the least, like me—and I'll warrant that virtually every kid on this panel went to a Head Start type of preschool, enriched preschool experience—the kids who need it the least get it the most, and the kids who urgently desperately need it as their last failsafe chance to make an education get it less than—about one- eighth of them our society is providing Head Start to.

Now I ask you, as a military man and as a man concerned with a competent, effective, skilled competitive work force, can you see the link between education-inadequacy, or education failure by the time the kids are 17 or 18, and the failure of our society to give them a head start?

Can you comment on the failure of our society to provide Head Start to the 86 percent of kids who aren't getting it now?

Secretary WATKINS. Let me try to respond in two ways, Congressman Scheuer.

My experience on the AIDS Commission gave me data that said that at the time of entry into kindergarten we can predict failure by a factor of four to five times on those that have not been through the proper preschool preparation, and primarily in the area of health, as well as identifying psychosocial issues as well as real physiological issues that a child may face, and move into the first competitive atmosphere that child has ever been in and be destroyed very early.

So I'm just telling you in one area alone we can predict failure for primarily the underclass and underprivileged by a factor of five before they get into kindergarten. Now that can be remediated in great measure by stop calling these things child care centers and start making them child development centers. We don't take advantage of the opportunity that is there with a handful of trained technical people to identify the cognitive development problems early. We ought to stop supporting child care and go to child development centers which does the same thing, but much better.

Now we're going to set up a child development center at Department of Energy—we don't have any now—and we're going to do it at Germantown. But that's going to have technically trained people who can monitor these youngsters and refer them to Head Start.

Somebody has to lead. And you have to take a lot of those parents—you have to lead them to water on this issue and say: Look, we have your child here, come with us and join with us on observing what is going on here. This child has a hearing problem, a sight problem, a cognitive development problem. They're struggling along and will never survive in school so you've got—here is a program we recommend for you, in fact, we're going to take you down there and get it to work.

So that's the kind of community service involvement we all have to get into in a much bigger way. So I really do believe that that is the key to building up the numbers downstream, whether it's math, science, engineering or others. But you have to start somewhere.

And that certainly would eliminate some of the tremendous problems those youngsters face early on, and then have a proclivity to drop out and quit in society and build up that constant state of hopelessness they find themselves in in one-quarter, if not one-third, of our kids out there right now.

Mr. SCHEUER. Would you say it ought to be a matter of high national priority to afford every educationally- disadvantaged kid at severe risk the benefits of this kind of preschool development program, Head Start program, whatever you want to call it?

Secretary WATKINS. I probably think it's the linchpin of the long-term good of the nation. I really believe that. But you can't just leave it at just preschool. You have to have a continuum of these things all the way through the process from preschool up through baccalaureate and graduate level.

Mr. SCHEUER. What you're in effect saying—and I don't want to put words in your mouth—that we ought to extend the public education system downward by two years to include these kids in an enriched development program in their third and fourth years?

Secretary WATKINS. Well I would hesitate to give the public education system one more task. I don't think it's doing awfully well today.

I would like to see us say that we, the adults of society, in a public/private partnership, are going to get in the middle of this thing. And American industry is going to start picking up the ball to help us move this thing in their own best interest. So this is a self-interest thing as well as goodness for society. And we haven't gotten that excitement yet out there that they're the ones who are going to pay the penalty downstream when the properly skilled people aren't there.

You talk to somebody like David Kearns of Xerox. He'll come before this Committee and tell you in chapter and verse how he has to re-educate and retrain to basic skill level of the work force.

Now we've got to stop that nonsense. We're putting $60 billion a year into retraining a work force that's coming out of our public schools now. So if you give the public schools another task, I think they'll go under. I think they need help, too.

But we've got to start getting everybody involved, or we're going to break the budget again in the United States. And I'm saying that we need to start doing this thing—and I don't think it's a great expense, I think it's a matter of focus, taking advantage of community-based relationships and getting public/private partnerships going in a real way, get serious about it.

Mr. SCHEUER. Thank you, Admiral Watkins.

Thank you, Mr. Chairman.

The CHAIRMAN. The Chair recognizes the distinguished gentleman from Pennsylvania, Mr. Walker.

Mr. WALKER. Thank you, Mr. Chairman.

Admiral Watkins, the Chairman and I have been talking in a preliminary sense about a new and somewhat revolutionary idea for assuring that some level of math and science competency at the local level and at the university level, and that would be to go to a system of federally chartering school systems and universities in the area of math and science, that we would offer federal charters that would be then accompanied by federal money if that school district's own universities showed a certain competency level in these areas.

I would appreciate your comments on that kind of concept, and whether or not that fits with what you just said a minute ago about providing some hope to the public schools and to the universities in getting over the fences that they now face?

Secretary WATKINS. The only problem I would see with it, Mr. Walker, is I think, if we set up any division of interest on math, science, and engineering to focus only on a few and have not tried a very solid core curriculum for the base of America, we're not doing it right. I think our society needs all of these people in the work force, and I'm afraid what would happen there is you would polarize again the math, science and engineering people off onto some other reservation that could be isolated from the mainstream.

I'm talking about a mainstream effort as well as best advice—I have no objection if that were to be an adjunct to a broad mainstream approach, but I do believe we've gotten to the point now where we've isolated those people as the nerds of society, instead of making them a part of our society in the mainstream.

I've been accused of, being an engineer all my life, that somehow I can't grasp the broader issues of the world because I'm an engineer or I'm interested in math. And we've got to get out of that kind of attitude which I only see coming through effort in the mainstream.

Mr. WALKER. What if you designed the charters in such a way that they went to a broad base rather than narrow base? The charter would not be exclusive but, rather, would be inclusive and so therefore would simply be aimed at assuring that people are bringing up competency levels rather than doing it in a way which is narrow and therefore restrictive?

Secretary WATKINS. Well Mr. Walker I'm going to be pushing everything I can in this area. It sounds to me like the idea has merit.

I don't hold the budget authority for education in the nation, I can only take what I've got, and I'll try to enhance that in the '91 budget with the Department of Energy. My job is to try to set a tone and a pace and an example because we have so many laboratories—maybe as many as 150 if we take it down to the smallest laboratory, that can influence nationally. And that's what I want to start doing.

I would encourage as much as we can possibly put into these kinds of scholarships and other programs, not unlike what we're doing in the—as I outlined in my detailed report of what's already underway, anything to enhance that obviously is a step in the right direction.

Mr. WALKER. It is something that we can count on your Department to work with us on if we went to a developmental stage on some legislation?

Secretary WATKINS. I'm not sure if I'm stepping over my bounds of authority as Secretary of Energy, as opposed to Secretary of Education. I'd have to really know exactly what we were doing, and I'd have to work with Secretary Cavasos on that.

Mr. WALKER. Sure—

Secretary WATKINS. I'd be glad to be a participant—I would hope that he would invite me to be a participant on that.

Mr. WALKER. You now understand why I'm very disappointed Secretary Cavasos couldn't be with us today, because it is precisely in this area that we should be discussing some things with him, and it seems to me, from the perspective of this Committee, we also would want to include the National Science Foundation and some other people.

But we certainly appreciate your good Department's willingness and ability to work with us in the areas that would be within your jurisdiction.

Secretary WATKINS. Thank you.

Mr. WALKER. Thank you, Mr. Chairman.

The CHAIRMAN. The Chair recognizes the distinguished gentleman from New York, Mr. Boehlert.

Mr. BOEHLERT. Mr. Secretary, I noticed on page 12 of your testimony you talk about DOE having the expertise and the labs and the spirit and I commend you for that. I would also like to note with a great deal of pleasure that we now have at DOE the enlightened leadership, so I'm very pleased to have you here.

I think with this very sensitive subject we have to begin at the beginning and we have to deal with the teacher problem, and there is a very real problem. We have been told in testimony that one out of three students in the New York Public School System—in New York City, that is, are being taught from other than certified teachers. We know that probably in our elementary schools of America we are having more history majors teaching science than we are science majors. We've got to do something about that.

And Mr. Walker and I have worked out a bill that we think supports the President's initiative, and I'd like to get your reaction to that bill. It's the bill that would provide stipends for juniors and seniors during their undergraduate years, $7,500 each year to help offset the cost burden of higher education, and in return for each year of the stipend the students would agree to teach two years at the precollege level. To me that addresses directly an urgent and pressing need, to get some of our best and brightest into the classroom.

What's your reaction to that, Admiral?

Secretary WATKINS. Well I certainly like the concept of involving the kids in our universities in the kind of teaching experience you're talking about. I believe we all have a responsibility in our society to participate in that kind of effort.

I question sometimes whether the stipend is the way to go. I really believe that we can engage our young people if we begin to start a concept of community service very early, say in kindergarten, where we build a core curriculum that inspires these people to help themselves, help others in society, and learn to serve others as well as self. And I think if we start that early in these programs that we will engender in these young people a strong desire to become involved in that kind of thing without stipend.

I just believe that we don't need to burden our educational resources, that are already strained so heavily on any one of these programs that we don't look to volunteerism on the part of youngsters to be a part of the solution.

Mr. BOEHLERT. Admiral, with all due respect, I'd like to find a pot of gold at the end of the rainbow, too. But as you also point out in your testimony on page two that students leave math, science and engineering fields to pursue what have come to be perceived as more potentially lucrative and less disciplined fields.

And the fact of the matter is the cost of a college education is just skyrocketing and many of these young students, when they get their undergraduate degree, also get a reminder that they owe $10- or $15- or $20,000 that they borrowed to get their education. Now I'm fully supportive of that program.

But I also think that in a way it might be called a bribe; I would prefer to call it an incentive. We would like to think that the spirit of volunteerism will catch us all up and we'll all run out and do it, but let's be practical. This is a practical approach to the problem. It gives them an incentive to do it. We do it in medically underserved areas. We've tried it in other ways. We do it with the ROTC program for our military. And I would suggest that education is extremely important and I would hope that you would give this some consideration.

Secretary WATKINS. Well I certainly, from my AIDS Commission experience, I found that the demise of the National Health Service Corps which—it does exactly that. In other words, if we inspire people to come into the medical profession and return seven years of service to serve in government and to serve in the underserved areas, this is a very important initiative.

It's quite possible that you could do something like that. I would demand much more payback. I would say let's go for the university—paying the university bill—much as Harvard and Yale have done for some students, bright students in business, that want to go into public service but don't dare try to go in at $20,000 a year starting salary. And go ahead and pay their first year if they spend three: or pay two years if they spend four: pay all four years if they spend seven years in public service afterwards, doing something like that. And I think teaching could be a part of that.

So the concept attracts me. I'm just a little bit worried about putting dollars out there that we raise expectations and then somehow we don't appropriate the money. It's just too high. Or we take it from other sides of the education till that are also desperately—

Mr. **Boehlert**. Admiral, just let me point out if I may—and I know that the bell has rung—but I applaud the President for his initiative and he's talking in terms of $10,000 scholarships, no payback requirement whatsoever, just to entice the best and the brightest to go on to college and major in math and science, no payback whatsoever.

I could make a good argument that I'm espousing good sound Republican philosophy: we'll give you something, we want something in return. So—

Secretary **Watkins**. I like the payback philosophy.

Mr. **Boehlert**. Thank you very much.

The **Chairman**. The Chair recognizes the distinguished gentle lady from Tennessee, Mrs. Lloyd.

Mrs. **Lloyd**. Thank you very much, Mr. Chairman.

Admiral Watkins, on page 13 of your statement you state that:
"...the potential of...laboratories to
provide major assistance to precollege and
university science education has only been
partially realized..." and I would like to expand on this statement as really, as I relate to my hearings I had in Tennessee on the role of the national laboratories. And I had three points I'd like to discuss with you.

One is, according to some of the laboratory personnel, in previous years the labs have had to keep their educational activities quiet because they were afraid they would lose standing if it was really known that they were that much involved in the education programs of our young people.

Have you considered the advantages or perhaps the disadvantages of amending the mission statements of the national labs to guarantee that these programs, their funding and the expansion of educational activities as the laboratories—

Secretary **Watkins**. It is the number one objective I have as Secretary of Energy. We're going to change their mission statement.

I've already had 20 of the laboratory directors in just the other day. This was the number one issue we talked about. They're enthusiastic about it. They're going to help me restructure it by coming back with programs. Part of our meeting in the fall with Dr. Glenn Seaborg, at the University of California, will gel this. We'll have a good agenda before we go out, and we'll harden that up, and then we'll start moving with it. And I hope to see—you'll see at least my portion of that in the '91 budget submission next year.

Mrs. **Lloyd**. Certainly this falls within the scope of your role, certainly, as Secretary of Energy.

Secretary **Watkins**. I don't think there's any question about it. I consider it the most important national resource problem the nation has, and I don't see why I can't do it in my area to try to help the Department of Energy out. We can't hire anybody right now to do the job we have to do. I can't pay them enough, and I can't find them. They want to work somewhere else.

Mrs. LLOYD. Two other areas:

The lab personnel expressed frustration over the amount of red tape necessary to provide some of the laboratory equipment to the public schools that they were not using; not necessarily obsolete, but it would certainly be an advantage of a high school or a college.

And the other area, the teachers at our hearings told us that the word of the DOE national lab programs for teachers was not circulated well, and how could we plan to greater outreach areas in this area?

Secretary WATKINS. I have two experts here that have been very supportive of my new initiatives to go after this in a much more institutionalized way, and perhaps they can expand a little on what outreach programs we have now and what we intend to do in the future. So maybe Ms. Joseph would address that.

Ms. JOSEPH. We have worked out an arrangement that as long as there is a memorandum with the school, like the adopt-a-school program with Woodrow Wilson, that equipment can be loaned for an indefinite period of time to high schools.

Department of Energy does have a unique regulation that we can give such equipment to universities. Now that has been expanded to the high schools, and the operations offices and laboratories across the county have participated in the adopt-a-school program and are making these kinds of equipment available, which is a high priority, for the high schools that they have adopted.

The outreach programs have grown significantly in the past few years at all of the laboratories—and we heard about them in Chattanooga—into the hundreds of outreach programs ranging from kindergarten and including families as well at each of the laboratories. And this is something that the Admiral encouraged in his meeting with the laboratories, and we expect to grow significantly in the next year.

Mrs. LLOYD. I might add one final point before my time is up. I really believe that we need technicians of all kinds in our scientific capabilities—not every science graduate can be a Nobel prize winner—and that we need to attract and excite the average students. And I hope that we can look to science and math and engineering programs that will be developed for the average junior high and high school student. Certainly we want to attract the best minds of our country, but there are a lot of minds out there that really need to be challenged and motivated as well.

Secretary WATKINS. I couldn't agree more, Mrs. Lloyd. You know, in the military we probably have the finest re- education and training program in the world. We would bring kids in from 10th and 11th grade educations and, within a few years, make them the equivalent of a Masters degree in certain very narrow areas where their motivation, their self-esteem is all built, such as in water chemistry, in a nuclear power plant or conventional boiler plant. And these kids, if you'll talk to them down in those places, those boilers, they'll talk to you about Ph, polarity, normality, exponential relationships, they can do everything. And they didn't go past 10 or 11 years, but they got motivated by us.

Why did they have to wait to come in the military? What's wrong with society taking these kids and finding their niches in life, and let them do something they can do well, one thing? And that's the whole idea.

So I really think that—that's what we've missed out on. We're always going for the brilliant scientists at the top and giving them all the kudos and putting them on all the talk shows and so forth when we ought to be saying, "Are you doing your very best." And take them up to that limit of their capability and put them into these narrow areas where we need them desperately.

In every one of my facilities, I could use that kind of technical skill right now. You do not have to have a genius across all disciplines in math, science and engineering to be able to have a productive worker in a highly-skilled field, providing you focus them on the narrow area they can really master.

And that is what we have not done well anywhere—our counselors in schools or anywhere else, except the military because we have no choice. It's a volunteer military, and we've had to do all of the same kind of thing I talked about with Xerox: re-educate, retrain to basic skill level, motivate the programs, make them healthy, give them an environment that's acceptable. And that's expensive. And the Congress pays for that. And that's why we have a ready military, and it all deals with the same set of issues.

Mrs. LLOYD. Thank you very much.

Thank you, Mr. Chairman.

The CHAIRMAN. I thank the gentle lady.

The Chair recognizes the distinguished gentleman from Pennsylvania, Mr. Walgren.

Mr. WALGREN. Thank you, Mr. Chairman.

It certainly is interesting to see the range of programs that the Department of Energy has developed, and I'm sure largely by themselves because they see a need there and fill it. And I take some satisfaction that we, in looking at the National Science Foundation, have wished that we had a broader program, because it is a broad problem. And there certainly is a very real expertise to be contributed by an agency like the National Science Foundation.

But I was really interested in looking at your undergraduate science education programs, one in particular: the example that you cite in your appendix is how experience in the national laboratories can literally change careers. And your example is of a young person who was an agricultural—a lettuce picker in the California valleys, going to night school at a local community college. But with acceptance into a DOE research appointment at the Berkeley Lawrence Laboratory, that person is now a full-time student in chemical engineering at Berkeley.

We have been trying to get the National Science Foundation to at least hold out some model, some national things to aspire to, to the community colleges and have just met resistance tooth and nail. And yet when an agency such as yours tries to make something happen, that is what really stands out. So I hope that other agencies can learn from the kinds of things that you've been able to do around the edges.

There is a similar point to be made in the paragraph before where you talk about the undergraduate student summer research participation program, apparently, according to the appendix, a competitively-selective program of research participation in the laboratories during the summer. And what stands out when you make a competitive selection is that one-half of the participants come from small, predominantly undergraduate institutions.

Now those are the institutions that the National Science Foundation completely misses because their focus is so completely on the large research university. They do not have substantial programs in small undergraduate institutions. And yet when you competitively select, half of your students come from those institutions; and, as you go on to say, 90 percent of the participants who were in this program go on to receive advanced degrees in science and engineering.

I just want to make the point that when an agency goes out and tries to meet the problem in a flexible, instinctively good response way, what you come up with will fill in the gaps that institutionally we have somewhat missed in our larger programs.

I wanted to ask also, you indicated in response to Mr. Brown that your instinct is to ask the University of Chicago to help you develop this program—

Secretary WATKINS. That's just one example. We have Dr.—

Mr. WALGREN.—students and the like.

Secretary WATKINS.—as mentioned earlier, Dr. Lederman, who was exemplary in this whole area and had his own visceral feel that was very much in synchronism with mine on this issue. And I was just mentioning that as one example to work with an area that is probably one of the most complex educationally in the nation. It has been denigrated by many; it is complex; it is filled with a high dropout rate, ethnic mix problems, et cetera.

There's a lot of effort going on. There are some wonderful community-based organizations trying to pick up the pieces. And I think we, in that area, can maybe have a demonstration project along the lines I've outlined here that can have a national impact. That doesn't mean we only focus on university or college. That happens to be near the Fermi lab where there's exciting work going on for the nation.

Mr. WALGREN. Well just if I might, Mr. Chairman, I'd like to suggest that perhaps the Department of Energy could require universities who receive substantial research support to act as brokers of this kind of volunteerism.

Obviously, the incorporating of volunteers in connection with any individual student or any individual program is something that has to be worked out totally on the local level, but in a sense one approach is to ask that every scientist be a teacher. And the problem is they don't have any real nexus with which to connect to the individual students or the individual programs.

And maybe through the Department of Energy you could have the universities at least trying to be connectors of people who might come forward either from the laboratories directly, your own scientists, but other scientists as well, so that there is a central place they can go to be connected to a volunteer contact and teacher/mentor program.

Secretary WATKINS. You've just defined our concept, Mr. Walgren. That's what it is. It is a very closely-knit—going to be a closely-knit arrangement, and those universities that receive large funds from us I've been told would be pleased to join us in this effort.

Mr. **Walgren**. Well we want to encourage it.

I thank you, Mr. Chairman.

The **Chairman**. The Chair recognizes the gentleman from Illinois, Mr. Fawell.

Mr. **Fawell**. Thank you, Mr. Chairman.

Actually, so much of what has been said I agree with very much, and I would make a couple of comments that I had in mind.

The outreach programs which, Admiral, you are talking about I so very much agree with. The concept, as I gather you're saying, this doesn't take a whole great infusion of new money but—using your own words, it's not a matter of money but of focus and setting a tone and a base. And I agree so very, very much.

I can, as I indicated in my opening remarks, refer to my own district: my wife happens to be a school teacher of the 5th grade in Scott School in Naperville, Illinois. And she has utilized the people at Argonne and Fermi, let me tell you.

I don't know if there was necessarily from DOE any great emphasis, any concept conveyed to the people at Argonne that this is something we ought to be doing, but at any rate it was being done and is being done in my area and Fermi also. I don't know if that is true nation-wide, but the many wonderful things that are happening in our area are happening elsewhere.

I mentioned the fact that Leon Lederman, who I think is going to the University of Chicago with the idea of education as a very practical concept in a very broad way, not just for the type of intellectuals that may go to the University of Chicago, I think he has a much broader concept.

But that I think we—and I gather this is exactly what you're saying, the message is being conveyed to all our federal labs: use every bit of expertise and influence that you may have—and, as has just been indicated, Argonne is being operated by the University of Chicago—yes, you do have influence, put that influence to work.

We have—the Math and Science Academy of Illinois is now—people from all over the world are coming to this Academy. And here I must confess we are looking at the very best of students throughout the State of Illinois, bringing them into that rarefied atmosphere, so it's not quite as broad a concept as you're talking about, but the brain child was Dr. Lederman from Fermi labs.

And we also had recently another gentleman from Fermi lab who has had the drive of what we call sci-tech, which is, you know, a technology museum where everybody in the community can utilize this museum for hands-on experience. There's a Clark machine there which was a former slot machine that has been developed into what they call a Clark machine and you can see illustrations of superconductivity.

So I just simply want to say that I know that DOE has this tremendous potential and it's more than just people talking and lecturing, it's—if you hear, you may not remember very much, but if you see you remember a lot more.

And if there's a hands-on experience—as just yesterday, in fact, in talking to my wife last night she had somebody in from Argonne who talked about these new levitated trains and the concepts that have been worked out at Argonne, the only place in the world where we're talking about these new high speed trains to be operated by airlines industries and so forth, just tremendous concepts. And she was so enthused because the students, the 4th and 5th graders, were just held in awe. And undoubtedly you're going to cause people to think in very practical terms that what you can see and observe you're going to encourage young people.

And I know that you're the Department of Energy, you're not the Department of Education and there's just so much that you can do, but I congratulate you for having this kind of emphasis because I think it is so very, very practical.

And I would encourage you to also let the employees know that, Hey, this is not something we're going to frown upon in any way, if you have concepts and ideas such as sci-tech as in DuPage County, Illinois, for instance, that has come into being and the Math and Science Academy, and want to give up your time, we encourage you to do that. That can be, I think, very important.

Secretary WATKINS. I think it's a matter of having these enthusiasts and these local leaders come out of the woodwork, come out of the cold, into the open under a very clearly announced policy so that there's no question. Also, it can be reflected in modest adjustments in the budget up to do what they have to do out there.

Argonne, as you know, receives I think the largest of our DOE education budget dollars. And so, to me Argonne and Fermi then in combination kind of can take on the inner-city problems, in my opinion, in Chicago by this kind of leadership and inspiration.

And this is why I believe it's so important to go for the central of our youth, as well as the best and the brightest. We'll do both; because, if we pick up the middle, we'll pick up the top and give them some motivation that this is of interest to the nation as a whole, so that those that then aspire to go on and have the potential to go on to graduate work and doctoral level work and that kind of thing would be enhanced in numbers.

So I don't think you just, by going toward the middle, do you ignore the top. In fact, you pick everybody up by their bootstraps.

Mr. FAWELL. I thank you.

The CHAIRMAN. The Chair recognizes the gentleman from Illinois, Mr. Costello.

Mr. COSTELLO. Thank you, Mr. Chairman.

Admiral, I, too, appreciate your appearance before this Committee this morning.

In your testimony—and you have referred more than once to it this morning—you have indicated that we need to have a partnership between the public sector and the private sector to address the problem. And I'm wondering how much coordination there is between the different Federal agencies that fund science education?

Secretary WATKINS. Well I cannot tell you, Mr. Costello. Maybe one of my colleagues here from the Education Branch of the Department of Energy have a better feel. I don't have that information in hand now, I haven't been there long enough to really study how that works. I know that it's not adequate at this point within the Department of Energy, but I'm not sure if one of my colleagues can answer about how it is interagency-wise.

Ms. JOSEPH. We work closely, of course, with National Science Foundation, as do the other mission agencies, and we're even working toward the possibility of the National Science Foundation jointly supporting the activities of the national labs, some of which are already underway, including efforts at Fermi lab. I think we have room for improvement, and we will do that.

There is also interagency efforts relating to Economic Policy Council activities, and there have been in the past through Office of Science and Technology Policy. And I'm sure under Mr. Bromley that that will probably increase.

Mr. COSTELLO. One other question, Admiral:

What is the total funding level for DOE precollege and undergraduate science education programs?

Secretary WATKINS. I think I've mentioned that in my testimony. It's $12 million.

Mr. COSTELLO. You mentioned $12 million, and I wondered what percentage of that $12 million is spent on teacher training?

Ms. JOSEPH. Teacher training we've gotten involved in only in the last two years. There are 150 high school teachers that are in an honors program, a six week program at the laboratories now. So it's a small part of the funding, but it's looked at as a targeted effort for 1990 to increase that number as well.

Mr. STEPHENS. If I may also project, Mr. Costello, a lot of our outreach in the national laboratories is to the local element in the secondary schools. So a lot of that is off-budget in the technical sense, but indeed it's a very important aspect of our work with science teachers.

Mr. COSTELLO. Thank you, Mr. Chairman.

The CHAIRMAN. The Chair recognizes the distinguished gentleman from Texas, Mr. Hall.

Mr. HALL. Thank you, Mr. Chairman.

I think I'd be remiss if I didn't congratulate the Chairman on these hearings. I think probably these could be as important hearings as this Congress will participate in in this session or any other session.

You know, if you really stop and think, if we could improve or continue to entice students and teachers back into these fields, that would address the problems we have with the deficit, unemployment, imbalance of trade, national defense, and you can go right on down. So I certainly congratulate you for giving your time, Admiral, and your staff's time for these hearings.

It seems to me that several years ago, Mr. Chairman, maybe back in '82 or '83, Dave McCurdy, Congressman McCurdy, had a bill to encourage assistance for teachers, to encourage them to come into this field—not considered the most spicy field in the world at that time—and we held a hearing at the University of Oklahoma. At that time, I must admit, they had $30 a barrel oil, and they were having trouble getting people into the teaching profession.

But we had testimony there that they would view—in order to get one general science teacher in the high school, they'd have to visit with 50 or 60 to find one that was capable and also wanted to. That's just one of the problem is enticing good teachers into this field that is so very important.

As I received the notice, Admiral, from Chairman Roe about these hearings, it coincided with a notice that I had to attend a function in my district at E-Systems, a defense contractor in Greenville, Texas. And I'm sure all of us across the way here have entities like that that can be of use and service and obtain the goal that you're trying to reach.

I attended that function that evening, and theirs was a recognition of students and teachers. And it was more than a recognition. They funded a lot of them. And it was beneficial to them. And I think that's something that—I'm not so concerned about Federal efforts in science and mathematics education at the precollege level being unified in one agency or spread out over a group; but, however it's set up, doesn't it make sense to really tap or continue to tap people like E-Systems and defense contractor who, as they grow and spawn these people and encourage them and support them, they get them back, and it takes care of their workforce?

Part of the pay of a teacher is to see proper recognition of their product, too, and that also takes care of that.

I'd like to send you that set-up and what that one company—and I'm sure they do it all across this nation, but what they're doing in their home towns, where they have their entities, what they're doing to encourage this. And I think you'll be pleased with it. I'd like to send it to you for your—I don't have a question for you. But I thought it was so interesting that the Chairman had set up these hearings, and it coincided with something in my own district right there at my gates.

And I tell you, I was amazed at the quality of these students and how, with the encouragement of a local entity—not just encouragement but hard dollars in cash that they put on them—what that did to the class of attainment, to the caliber of attainment, that these students acquired. They were accepted at MIT and schools all over this country, that I couldn't believe that those schools in that size city, which is under 30,000, would attain.

But there's a lot of untapped resources out there, and I know you're aware of that. And I know it takes money to tap those resources.

So I just want to congratulate you on what you've done and this Chairman for setting up this, probably the most important hearing that this Congress will attend this year. I yield back my time.

The CHAIRMAN. I thank the gentleman from Texas.

The Chair recognizes the distinguished gentleman from North Carolina, Mr. Price.

Mr. PRICE. Thank you, Mr. Chairman.

Admiral, I want to commend you for an excellent statement and for your expressed determination here this morning to step up your Department's education efforts.

I am particularly struck by the first two recommendations you make in your statement:

The first on increasing our emphasis on the middle school years, recognizing as you do that those are critical years when kids begin to feel that they can or cannot do math or do science—often if we reach kids in those later high school years it is too late; secondly, your focus of more attention on average students and on the importance of building a broader base in our society for technical literacy.

I'm struck by those two recommendations in particular because they do reinforce things we've heard in this Committee before: hearings we've held about the workplace of tomorrow; the requirements of workplace literacy, also a Sun Belt Institute study, which I co-chaired, which pointed up the educational training requirements in the workplace of tomorrow.

We do face an alarming and a growing gap in this country between what an increasingly sophisticated workplace is going to require and what our young people are bringing to that workplace. And that's a gap we've got to close if we're going to reap the human potential of economic development, to say nothing of maintaining this country's competitive posture.

Making those statements, those recommendations as you do though does raise a question of what kind of position you are in in your Department to implement such recommendations, raises a question of what kind of cooperative relationship exists between your Department, the Department of Education, the NSF and other agencies that might be in a position to act on those very insightful recommendations.

Could you comment on how much and what kind of coordination does exist between your agency and other relevant Federal offices?

Secretary WATKINS. Let me just touch one of the issues that you raise, Congressman, now. I'll have to defer to the others again on expanding on any of the prior testimony given on the intergovernmental agency cooperation.

I don't think it's a matter that we don't cooperate. I think we do. I think what has not happened is we haven't had the dedicated leadership at the very top to take hold of this thing and bring everybody forward as a nation to start moving this goodness that was mentioned here earlier by Mr. Hall that sits out there waiting for martialling by the President, which he is trying to do now through a number of programs. It does take time to move the nation, but I believe that everybody is ready and in the starting blocks out there to move.

I believe that we are at a very critical turning point for the nation, and we can at the Department of Energy do a lot to inspire others. We don't—the President has told us all at Cabinet meetings that he expects us to be a part, a participatory part of this government. And we do speak out in meetings across our normal lines of authority. He has allowed me to come forward and introduce his YES to America concept, which is a Youth in Service to America service concept that he is trying to establish a foundation for and get the spirit moving in the nation that we all need to help to pull us up.

I intend to be a participant in the forthcoming Carnegie Council on Adolescent Development, which we'll be presenting on the 19th of June, a brand-new middle schools curriculum concept for the nation, with two years of research behind it from some of the best minds in the nation. That will focus a new concept out there that says youth community service, health education, health promotion in very fundamental ways, such as understanding our own human biology, have to be key elements of the core curricula of the nation.

And we have to have an integral concept of life sciences development over the continuum of school years, or we're not going to make it.

And it's all in there, and it's all been researched so we know what to do. And we're going to come out with that as a module in an area that is called middle school, that is totally unaddressed in the nation.

Everybody says we're going to fix it in high school with bandaids, and we're trying to do that. We've got more courses now on safe driving and sex education and all those things when we've lost the fundamental touch of why do we need to do all that if we can get the kids to say no to drugs themselves, rather than somebody telling them to say no because they understand what they're doing to themselves in the process. We don't educate them to that level.

We know very little about our own human biology as adults. We have to lean on everybody else. But you go to AIDS patients, and they can tell you more about their immune systems than most doctors in the country. And they aren't that well educated in many cases.

So these are the kinds of things I think we have to start doing.

And in that particular conference that we're having here in Washington, I'm going to be on a panel with Senator Nunn and the President of the Education Commission of the States, and Nancy Kassebaum's going to be over there, and the President has invited—and I hope he can come. Governor Kean will be giving the opening address. And we're all dedicated to somehow get the nation inspired to move in this direction.

So I do have an opportunity to influence. I'm a Cabinet member. The President has asked us to get involved—to get involved in these things. He's invited me to go ahead and give testimony this morning on education.

And I think it's an all-hands evolution. I don't think we can stick to the Department of Education alone. We're all in this game. They have a certain element of it.

It's probably an archaic system the way we run the Education Department. I think maybe the breadth of education is so tremendous it goes into Health and Human Services, it goes into Energy, it goes into Defense. It's all over the place.

And we can't just lean on Secretary Cavasos for action. We ought to all move, every one of us. So let's don't put all the burden on Mr. Cavasos. He's a good friend of mine. He wants to cooperate. He's very sympathetic with my views. And maybe I can be a catalyst to help move and help him out in inspiring others to let him move some of his programs.

I don't have any problems with coordinating at the highest level, but we haven't even been in business long enough to really get moving on this kind of issue.

And I hope the new Science Advisor to the President, who has been raised to the National Security Council equivalent—or the National Security Advisor equivalent—will be a prime mover to coordinate the interagency effort at a very high level right under the President to get this thing moving in a big way.

Mr. PRICE. Thank you. I commend you for that statement.

Of course it's true that this is not the responsibility of any one agent or any one department. I do think it's important to know, though, that the recommendations you've made here today are very broad based. They do have implications that go far beyond the rather modest set of programs that are located within your Department. I'm glad to hear that these iterations, the efforts are underway.

My time is expired. Thank you, Mr. Chairman.

The CHAIRMAN. The Chair recognizes the distinguished gentleman from North Carolina, Mr. Valentine.

Mr. VALENTINE. Thank you, Mr. Chairman.

I don't mean to suggest by this statement that the solution of the problems which we're talking about here, Admiral, is as simple as building highways and bridges and other parts of the infrastructure. But it would be difficult, I think, to imagine the situation that our country would be in today without the interstate highway system.

The interstate highway system was successful because it involved every part of the country. It's impossible to have that unification without involving every part of the country.

I think that, if we are to accomplish the goals that you have enunciated here, in the minds of most of us, if not all of us, it is absolutely essential that there be a means of very unusually, extraordinarily aggressive liaison between the Federal Government and the various states. This is not just having situations which are available to states if you can find them; not a continuation to use only the rapid paths that have existed in the past from academia in the different states to the Federal Government; but to be sure that all of the states are able to participate, and perhaps to the extent of the system of exchange students within the country, an exchange of teachers from school to school. You have probably touched on some of those things directly or by inference in your statement.

But would you comment further on that concept?

Secretary WATKINS. I'd like to ask Ms. Joseph if she would talk about what we're now doing in that regard. And certainly what you're saying is very much, again, in mesh with our feelings in our program, and how we're going to run this.

Maybe you can talk about that, Ms. Joseph, as to what we are doing right now.

Ms. JOSEPH. As you know, there are national laboratories located all across the country, and they have educational personnel that interact with the state personnel people. And that interaction has been increasing significantly.

We also have a high school honors program where the students are selected by the governors of every state to participate in a program at the national laboratories for what now reaches about 374 high school students. These efforts are underway to expand that, again chosen by governors and the state education office, to the high school teacher program which was done for this year and expect to put more emphasis on next year.

Mr. VALENTINE. Are you satisfied by the results obtained from that program, generally speaking? I mean do you feel that it works? Do you believe that what is available, that the states are taking advantage of it?

Ms. JOSEPH. Yes, sir.

I think there's a lot of enthusiasm for the pre-college programs, particularly, and mostly based on letters and anecdotal data rather than sophisticated evaluations. These programs have had an impact on the students. And the states are very supportive of them and of increasing them.

Mr. VALENTINE. Mr. Chairman, I know we have to leave. I'll make one other comment.

I wanted to compliment the gentleman on page 12. Since I've been in Congress I don't think I've ever had anybody come and say that we have enough dollars for the moment.

[Laughter.]

Mr. VALENTINE. And I just couldn't let that pass. I've never heard that before.

Thank you.

The CHAIRMAN. I thank the gentleman from North Carolina.

We will now recess to go vote. And, Mr. McMillen, you're up first when we return. I please ask the members to return with dispatch so we can conclude our findings this morning.

We'll be right back.

[Recess.]

The CHAIRMAN. The Committee will reconvene.

When we broke, we had to go vote. The Secretary had to leave and go to a Cabinet meeting. But we are going to call on Mr. McMillen from Maryland, who had a question.

And I do thank Ms. Joseph and Mr. Stephens for staying.

The Chair recognizes the gentleman from Maryland, Mr. McMillen.

Mr. MCMILLEN. Thank you, Mr. Chairman. I appreciate the chance to ask questions of staff here.

I have a concern about your foreign students in the states and, you know, where that trend is heading. I am curious as to experience in that regard.

When you look at all the statistics, the college age population declining by 25 percent and the growth in foreign students somewhere in the neighborhood of 20 to 40 percent of our graduates in science and math are foreign students—when you look at reciprocity, 20,000 Japanese students are in this country; we have 1800 in Japan.

Although I'm encouraged by the NSF study which says that about 60 percent of them want to stay in the United States and have plans to stay in the United States, I'm curious as to what are the ramifications of that over the long term.

And I know that DOE, because of the unique relationship between scientists and engineers—you can provide some background on this—I understand that you spent $400 million, according to Admiral Watkins' testimony, supporting 3500 to 4000 graduates. How many of them, for instance, are foreign students?

What is your experience in that area, and do you see this as an issue, a public policy issue that we should be concerned about in this country?

Ms. JOSEPH. On the university research support, which is the core support for graduate students, the support is given to research proposals that are competitively reviewed.

In the Department of Energy there is a policy, particularly in basic energy sciences, that these research proposals support a significant number of graduate students, which is the way we help to replenish the pool that we draw from for graduate students and scientists and Ph.D. scientists.

There isn't any record that's kept that says which of these students are American and which might be foreign graduate students. And if there were, you wouldn't be able to predict which of those foreign graduate students would choose to remain U.S. citizens and become a very important part of the university research community, as well as university teaching and as well, of course, in the private sector.

There is concern on the part of Department of Energy to increase the number of U.S. students, particularly in engineering. We do have programs, funded by each of our major research programs, for graduate students that are supported at the labs. There are American graduate students; there are 250 or so that we fund in my office a year. In addition, there are fellowships from the programs like fusion at about 20; fission at about the same number. Those program areas are also funding U.S. students on these fellowship programs in the Department of Energy, and I'm sure you'll hear more from the Department of Defense.

We also have a major nuclear weapons mission and do a significant amount of classified work. And foreign students aren't a resource that we can call upon for those kinds of important jobs.

So there is a real commitment to increase the number of U.S. graduate students, but also recognition that we need to try to influence foreign graduate students to remain in the U.S. and to enter the science and technology jobs here as well. But we're not doing very well on that point.

Mr. MCMILLEN. Let me rephrase my question a little bit:

Since you don't really have a data bank indicating what fellowships are going to foreign students, would it be safe to say that in this competition that there are in many instances grants given to foreign students over American students?

Ms. JOSEPH. No, definitely not. There is not—the competition is presented by the principal investor, who is a university research professor. And it's the graduate students that he pulls together for the team who support that research. And there would never be any hint that there would be any preference for non-U.S. students. The system is not geared that way at all.

Mr. MCMILLEN. Would it be possible to find out, out of that $400 million, how much of it—how difficult would it be for your agency to figure out how much of that is going to support foreign students?

Ms. JOSEPH. We will look at that, and we will provide it for the record. It would be a little difficult, but I think that we could do it.

Mr. MCMILLEN. That would be fine.

Thank you very much.

The CHAIRMAN. I thank the gentleman from Maryland, and I want to thank our two witnesses for staying and helping us out. If there's no further questions, we'll call the next panel.

Ms. SCHNEIDER. Mr. Chairman, may I just ask a very brief—

The CHAIRMAN. Why the gentle lady most assuredly could ask a question.

Ms. SCHNEIDER. Thank you.

Actually it's—

The CHAIRMAN. The gentle lady from Rhode Island.

Ms. SCHNEIDER.—not exactly a question, but I would like to know that since the Admiral has placed particular emphasis on the understanding of math, I am very much concerned that the whole philosophy of cost-benefit analysis be incorporated in the Department of Energy period. And I think that one of my great concerns is that when we're dealing with energy we have failed to look clearly at what are the most cost-effective investments. And I think that clearly in the form of any kind of education, whether it be for energy policy or whether it be for business, you have to do a cost-benefit analysis. And I think this is sorely where the Department of Energy has fallen down in the past. And if math is so very important, I would like to see that statement integrated into the proposals that are being put forward by the Department of Energy.

I am very hopeful that under Admiral Watkins' leadership we will see a new twist of the approach to the expenditure of our dollars for the Department of Energy.

Ms. JOSEPH. I think you will see an increased emphasis on math. And in the pre-freshman engineering program that's run out of our office, the emphasis is on math and science for sixth through tenth grade minority women students. We reach 2000 of those students a year. That's our most significant math enrichment effort by a mission agency department. And based on what the Secretary has said, this will be one of the targets for increases in the future.

Ms. SCHNEIDER. Well my point is less focusing—having the Department of Energy focus on teaching math than have the Department of Energy practice what it preaches.

My bottom line is that the Department of Energy is not doing a cost-benefit analysis when it comes to energy policy, and I think that it would be helpful to have the Energy Department involved in educating our young people to understand that we have to work on the bottom line, whether we're in the government or in the business community. And clearly the Department of Energy in the past has not put forward the most cost-effective energy proposals.

Thank you, Mr. Chairman.

The CHAIRMAN. I thank the gentle lady.

The Chair recognizes the gentleman from Pennsylvania, Mr. Ritter.

Mr. RITTER. Thank you, Mr. Chairman.

I just want to commend the Admiral and his team, Mr. Chairman, for I think providing the kind of leadership in the Department of Energy that we really haven't seen in a long time. And the aggressive, enthusiastic, public- oriented, action-oriented approach of Admiral Watkins, I think, is refreshing and I think it can take advantage of the enormous resources that are subsumed in the Department of Energy.

I want to ask you whether or not, in your dealings with the Education Institute, you have been participating in the AAAS, the American Academy for the Advancement of Science, program on scientific literacy? Are you engaged in that effort?

Ms. JOSEPH. Only peripherally. We have some people who are parties of Department of Energy who are involved in that. We aren't supporting it directly in the Department of Energy.

We are aware of the AAAS and laud that effort particularly.

Mr. RITTER. I might point out this is their Project 2061, which indicates the return date of Halley's Comet. Hopefully, we don't have to wait until 2061 to get our education house in order; too many ballgames will be over by then.

But they are doing a job of trying to integrate across the different organizations and structures that have responsibilities in science and math education: private sector efforts, public school and private school efforts.

And it would seem to me that your conference in October, your October 9th conference—which I commend you on, I think it is extremely important, your starting to mobilize resources of the Federal Government to get behind efforts to adopt change in our educational structure.

But do you plan on integrating within that conference some of the tremendous footwork, groundwork that's been done by AAAS's Project 2061 in defining what is necessary, what is agreed upon, what is the consensus that the American people should know about science and mathematics? Is this a literacy factor?

Are you intending—

Ms. JOSEPH. The Secretary's direction to the staff, before setting up the conference, is to come up with a baseline, looking at all of the reports and all of the activities that are underway, insuring that we don't duplicate all of the good work that's already been done and then to try to come up with a baseline consensus of what is needed from those kinds of reports—including hundreds of others that have been done—all of this being done before the meeting is set up, before the agenda is established, insuring that those kinds of things are—

Mr. RITTER. Are you going to integrate some speakers and contributors from the private sector?

Ms. JOSEPH. Yes, he does plan to do that.

Mr. RITTER. Okay. Are you planning on inviting David Kearns, President of Xerox? I know the Admiral—

Ms. JOSEPH. He mentioned—

Mr. RITTER.—mentioned—

Ms. JOSEPH.—Kearns specifically, and we do have him on this list.

Mr. RITTER.—Mr. Kearns.

Are you familiar with Mr. Kearns' book, The Brain Race?

Ms. JOSEPH. I haven't read it, but I am familiar with it, yes.

Mr. RITTER. I think, if your function is to extend the Department of Energy's resources into grass-roots America to improve basic understanding of science and mathematics, it is an absolute must-read, The Brain Race.

Are you familiar, Mr. Stephens, with the book?

Mr. STEPHENS. Yes, sir, Mr. Ritter, and I also might add the Admiral has read that book fairly extensively—

Mr. RITTER. It's terrific.

Mr. STEPHENS.—and I think you'll sense some of that flavor in his testimony.

I also might add that Project 2061—Dr. Rutherford, the director of that project, is a member, a very active member of our Energy Research Advisory Board panel on DOE in education. And a lot of the flavor in that report—

Mr. RITTER. You know, it really is heartwarming to see that the massive resources of the Department of Energy, in terms of science and technology, are starting to be integrated into the real life of the American people. You know, in The Brain Race, there is talk of very, very substantial consideration for restructuring our public school system and for getting flexibility and choice and essentially trying to move towards an educational capacity that can solve problems without the massive infusions of new dollars, which means structural change.

Are any of those policies being used in your own dealings with this problem?

Mr. STEPHENS. We recognize, again, that what this Department brings to this issue is essentially scientists who themselves are enthusiastically involved in science education. In fact, many of our scientists at national laboratories really are frustrated educators in their own way, and they also are concerned about where will their next—their clone come from, who will replace them in the scientific workforce.

And there's a tremendous pent-up enthusiasm to work with the school system, both with the formal school system and with the out-of-school school groups, through science museums and other activities, that I think we'll see some real progress over the next several years.

Mr. RITTER. Let me ask you—just one last point, Mr. Chairman:

Obviously the federal labs and the national labs and DOE organizations have fantastic potential to be a major player in the evolution of a better American educational system, particularly in science and math. But, also you are a big contractor. You have a significant tie with the private sector.

Are you seeking to bring some of these newer ideas and amount of forces into the private sector through your contractors to the American people?

Ms. JOSEPH. He does plan to look at that in the conference in Berkeley and to see what the possibilities are for—

Mr. RITTER. I would say there is just tremendous potential there. The Department of Defense, for example, in adopting total quality management requirements for defense contractors has really accelerated the onset of the quality revolution in a whole host of high-tech aerospace and electronics firms that might just not move so fast unless their big customer was interested.

And I just lay that out as a possibility for you. I mean, you are the customer to a significant technology- oriented group of American companies and you could influence their actions in this area.

So thank you, Mr. Chairman.

The CHAIRMAN. The Chair wants to thank the witnesses very much for staying with us and rounding out the rest of Admiral Watkins' testimony. Thank you very much. We appreciate your help.

The Chair wants to call the next panel. The next panel will be made up of Dr. James B. Wyngaarden, Director of the National Institutes of Health, Dr. Charles E. Hess, Assistant Secretary of Agriculture for Science and Education, accompanied by Dr. Alvin Young, Director of the Office of Agriculture Biotechnology, Dr. John Moore, Deputy Director of the National Science Foundation, Dr. Robert W. Brown, Director of Educational Affairs Division, Office of External Affairs, NASA, and Dr. Frank Cipolla, Director of Management, Civilian Personnel Policy, Department of Defense.

We want to welcome all of the witnesses on this panel, and we do appreciate your patience in being with us.

All of your testimonies will appear in full in the record. And I think it would be most productive to use your time effectively so that we can get to questions and answers.

Having said that, the Chair first will recognize the distinguished Director of the National Institutes of Health, Dr. James B. Wyngaarden as the opening witness.

Dr. Wyngaarden, welcome.

Dr. WYNGAARDEN. Thank you, Mr. Chairman.

The CHAIRMAN. And those microphones are tough to hear by so you have to pull them closer to you.

STATEMENTS OF DR. JAMES B. WYNGAARDEN, DIRECTOR, NATIONAL INSTITUTES OF HEALTH, DR. CHARLES E. HESS, ASSISTANT SECRETARY OF AGRICULTURE FOR SCIENCE AND EDUCATION, ACCOMPANIED BY DR. ALVIN YOUNG, DIRECTOR OF THE OFFICE OF AGRICULTURE BIOTECHNOLOGY, DR. JOHN MOORE, DEPUTY DIRECTOR, NATIONAL SCIENCE FOUNDATION, DR. ROBERT W. BROWN, DIRECTOR OF EDUCATIONAL AFFAIRS DIVISION, OFFICE OF EXTERNAL AFFAIRS, NASA, MR. FRANK CIPOLLA, DIRECTOR OF MANAGEMENT, CIVILIAN PERSONNEL POLICY, DEPARTMENT OF DEFENSE

Dr. WYNGAARDEN. Thank you, sir.

Mr. BROWN. Mr. Chairman.

The CHAIRMAN. The gentleman from California.

Mr. BROWN. Mr. Chairman, I apologize. I have to be temporarily away for a moment or two.

But could I say a word about Dr. Hess, who will be appearing on this panel?

The CHAIRMAN. I was thinking about saying something about Dr. Hess myself.

[Laughter.]

The CHAIRMAN. But in view of the fact that you are from California—

Dr. MOORE. Only if it's decent.

Mr. BROWN. We both ought to say something about Dr. Hess.

I wish to point out that this is his first official appearance since he was sworn in on Monday as Assistant Secretary of Agriculture for Science and Education. And I'm very proud of the fact that he comes most recently from California.

The **Chairman**. Most recently, that is.

Mr. **Brown**. Most recently. But I'd be remiss if I didn't point out that he originated in New Jersey.

The **Chairman**. Wayne, New Jersey, to be exact.

[Laughter.]

Mr. **Brown**. He received his fundamental training in New Jersey—

The **Chairman**. At Rutgers University.

[Laughter.]

Mr. **Brown**. You're going to upstage me no matter what I do, aren't you?

[Laughter.]

The **Chairman**. His good mother and father were personal friends many years ago of my mother and father in the Township of Wayne. And his dad served on many of the important boards of that community. So we trained him well in New Jersey knowing that he'd be able to carry on the affairs of state, certainly in California, and now as the new Secretary.

Mr. **Brown**. Well, I think this bodes well for our cooperation in making sure that the many new initiatives in agricultural science which I'm sure he'll be promulgating will be well received in both the Committee on Agriculture and the Committee on Science.

The **Chairman**. I would think so, particularly the Chairman of Agriculture coming from California.

Mr. **Brown**. Correct.

Thank you, Mr. Chairman.

The **Chairman**. All right. Now do you want to take it on from there, Dr. Wyngaarden?

Dr. **Wyngaarden**. Thank you, Mr. Chairman.

The **Chairman**. The Chair recognizes the distinguished gentleman.

Dr. **Wyngaarden**. I'm tempted to continue in this vein for just a moment and point out that I was born in Congressman Henry's district, I live in Mr. Valentine's district and was a colleague at Duke University with Congressman Price, just to continue these personal associations for a moment.

I am the Director of the National Institutes of Health, and I have been asked to discuss activities by which the National Institutes of Health supports precollege and undergraduate education in science, mathematics and engineering.

At the NIH, in line with our mission, these activities are confined to the biomedical sciences.

The Government-University-Industry Research Round Table of the National Academy of Sciences projects a continuing strong demand for scientists and engineers in the United States but a decline in the numbers of Americans in the appropriate age groups for involvement in these professions.

Dale Corson, President Emeritus of Cornell University, recently wrote:

"Children are being turned off to science,
beginning the first day of the first grade."

He warned:

"The problem is so deep that I think it
will take generations to solve."

In connection with its Centennial observance, the NIH began in 1986 to work with other government agencies, academia, and industry to address more directly this problem. Those involved have become known as the Partners in Discovery: government, academia, and industry.

Encouraged by the positive response to our initial efforts, last year I established an advisory group, consisting primarily of NIH Institute Directors, to develop a plan to improve biomedical science education and to attract young people into health research careers. The group will also advise the Director of the NIH on specific proposals for accomplishing these goals.

Last week at a meeting of the Advisory Committee to the Director, representatives from other government agencies, industry, health voluntary and professional organizations, and universities examined recent demographic and sociological trends, assessed their implications for the pool of biomedical researchers, and suggested strategies for sustaining the quality and level of effort of the research.

The message is clear. To maintain the current pace of scientific advancement, and particularly to press forward on such initiatives as biotechnology and the human genome project and the expansion of research on AIDS, we must ensure a continuing supply of bright, well-trained scientists. To accomplish this, we need to attract more young people into the pipeline.

The NIH recognizes the interdependence of science education, research training, and the successful conduct of biomedical research. This linkage provides the opportunity for the development of the next generation of scientists in the same laboratories where new discoveries are being made.

NIH provides over $240 million annually to support approximately 11,000 graduate students and postdoctoral fellows through National Research Service Awards and $96 million to support about 1300 additional postdoctoral researchers in Research Career Programs.

These research training programs of NIH serve several functions: They attract students to research careers; they enhance research environments; and, most of all, they ensure the nation's research enterprise. The success of these programs, however, ultimately depends on the number of students in primary and secondary education who choose science as a career pathway.

And as a means of stimulating the interest of precollege and undergraduate students in the biomedical sciences and health research, I would like to mention a number of the important activities that NIH has undertaken.

All of the NIH entities participate in government-wide recruitment programs. The Stay-in-School and Summer Aid Programs provide work experience for individuals who need income to remain in school. Many of the students become interested in science by working in the laboratories.

Most NIH formal training and education programs involving precollege and undergraduate students target minority groups. These programs include the Minority Access to Research Careers, or

MARC Program, which comprises the Honors Undergraduate Research Training Grants and the Faculty Fellowship Awards; the Minority High School Student Research Apprentice Program; the Minority Biomedical Research Support Program; and the Research Grant Supplements for Minority Undergraduate Students.

Under the Honors Undergraduate Research Training Program, administered by the National Institute of General Medical Sciences, 56 minority institutions are receiving support. A congressionally established Task Force on Women, Minorities and the Handicapped in Science and Technology stated that:

"...of the Federal programs established
to give minorities and women access to science
and engineering, we found the MARC closest to
what we need today...a prime example of a
successful Federal intervention program."

The MARC Faculty Fellowship Award provides opportunities to strengthen research and teaching programs in the biomedical sciences for students of colleges whose enrollments are drawn substantially from minority groups.

The Minority High School Student Research Apprentice Program, administered by the Division of Research Resources, gives minority teenagers the opportunity to work with biomedical investigators who are committed to broadening their scientific understanding and teaching needed skills.

The academic institutions themselves have come to realize the value of this program in providing students for their own graduate and health professional schools and have matched NIH funds with institutional contributions. Since 1980, when it was established as a Presidential initiative, this program has funded nearly 7000 summer apprentices.

The Minority Biomedical Research Support Program grants support a program administrator, student research assistants, and groups of individual research projects at each participating institution. The funds permit faculty members, who frequently have prohibitively heavy teaching loads, to allocate more of their time to research. Students are given the opportunity to do actual research.

The MBRS program has provided resources for over 90 minority institutions to engage in biomedical research and to update their science curricula. Close to 16,000 students have been involved in research to date and about 80 percent of these are in the pipeline as potential biomedical researchers.

Other training programs and efforts to stimulate interest in biomedical science are sponsored by several of the Institutes. NIH estimates that it will spend almost $50 million in fiscal year 1989 on educational initiatives and programs, some of which I have described.

In cooperation with nine private sector companies and the New Jersey Business Industry and Science Education consortium, NIH is developing a new education curriculum, Health Careers in the Health Century, to present a broad range of health science career options. The program will be tested early next year in New Jersey. We have the expectation that it will eventually have nationwide distribution.

In addition, NIH and NASA are collaborating in plans to develop an educational program involving students and teachers in the June 1990 Spacelab Life Sciences I mission.

Biomedical science has never held greater promise for improving the health of the American people. To achieve that promise, NIH will continue to support the development of scientists who have the technical expertise, the theoretical grasp, and the long-range commitment to solving the mysteries of human biology in an environment of stable support.

NIH's mandate and resources require us to concentrate on support for advanced education and training so that our investigators can maintain U.S. preeminence in the biomedical sciences. However, we are dependent on the elementary, high school, and college educational systems. We hope that our modest attempts to reach students at these levels will help our nation address the serious problem of science education and perhaps serve as models for other programs.

We join you in exploring new and innovative ways to address the problems we are discussing today.

Thank you, Mr. Chairman. I'd be pleased to answer any questions that you or the Committee might have.

[The prepared statement of Dr. Wyngaarden follows:]

FOR RELEASE ON DELIVERY

STATEMENT

BY

JAMES B. WYNGAARDEN, M.D.

DIRECTOR

NATIONAL INSTITUTES OF HEALTH

DEPARTMENT OF HEALTH AND HUMAN SERVICES

BEFORE THE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

MAY 24, 1989

Mr. Chairman and members of the committee:

I am Dr. James Wyngaarden, Director of the National Institutes of Health. I have been asked to discuss activities by which the National Institutes of Health supports precollege and undergraduate education in science, mathematics, and engineering. At the NIH, in line with our mission, these activities are confined to the biomedical sciences.

The Government-University-Industry Research Round Table of the National Academy of Sciences projects a continuing strong demand for scientists and engineers in the United States but a decline in the numbers of Americans in the appropriate age groups for involvement in these professions. Dale Corson, President Emeritus of Cornell University, recently wrote, "Children are being turned off to science beginning the first day of the first grade." He warned, "The problem is so deep that I think it will take generations to solve."

In connection with its Centennial observance, the NIH began in 1986 to work with other government agencies, academia, and industry to address, more directly, the problem. Those involved have become known as the "Partners in Discovery"--government, academia, and industry. Encouraged by the positive response to our initial efforts, last year I established an advisory group, consisting primarily of NIH Institute Directors, to develop a plan to improve biomedical science education and to attract young people into health research careers. The group will also advise the Director, NIH, on specific proposals for accomplishing these goals.

Last week, at a meeting of the Advisory Committee to the Director, NIH, representatives from other government agencies, industry, health voluntary and professional organizations, and universities examined recent demographic and sociological trends, assessed their implications for the pool of biomedical researchers, and suggested strategies for sustaining the quality and level of effort of the research.

The message is clear. To maintain the current pace of scientific advancement, and particularly to press forward on such initiatives as biotechnology and the human genome project and the expansion of research on AIDS, we must ensure a continuing supply of bright, well-trained scientists. To accomplish this, we need to attract more young people into the pipeline.

The NIH recognizes the interdependence of science education, research training, and the successful conduct of biomedical research. This linkage provides the opportunity for the development of the next generation of scientists in the same laboratories where new discoveries are being made. NIH provides over $250 million annually to support approximately 11,000 graduate students and postdoctoral fellows through National Research Service Awards and $96 million to support about 1,300 additional postdoctoral researchers in Research Career Programs. These research training programs of NIH serve several functions: they attract students to research careers; they enhance research environments; and most of all, they ensure the nation's research enterprise. The success of these programs, however, ultimately depends on the number of students in primary and secondary education who choose science as a career pathway.

As a means of stimulating the interest of precollege and undergraduate students in the biomedical sciences and health research, I would like to mention a number of the important activities that NIH has undertaken.

NIH EDUCATION INITIATIVES

In February 1987, the NIH brought 56 promising high school science students and their teachers to Washington for a special three-day educational program. The students were given an opportunity to chat with 17 Nobel Prize winners, to visit the National Academy of Sciences, to tour the NIH laboratories, and to meet with NIH scientists and physicians. In addition, each student received a special certificate and a $250 scholarship. Students and scientists alike were most enthusiastic about their experience, and we continue to receive appreciative letters from the students and teachers.

That fall, the NIH opened its doors to Washington area middle school and junior high school students. Approximately 4,000 students from 62 schools visited the NIH Visitor Information Center and the "Discovery Pavilion" where they viewed interactive exhibits provided by groups from NIH, industry, and local government.

NIH Office of Communications

Every week, two or three school groups tour the NIH and its labs, as well as receive an orientation in the NIH Visitor Information Center aimed at encouraging students to consider careers in biomedical research. In total, over 6,000 students and 300 teachers take part in these visits each year.

In addition, the Office is the NIH Adopt-A-School coordinator for Takoma Park Junior High School that has a magnet science and math program with a mostly minority student population. This permits a continuous round of educational activities and interaction.

NIH Symposia on Training and Career Opportunities in the Biomedical Sciences

The underrepresentation of minorities in science has exacerbated the problem of ensuring an adequate supply of scientists for future research endeavors. To rectify this, NIH is sponsoring a series of symposia, each targeted to a different minority population. At these meetings, students can talk with scientists and research support personnel who are engaged in a variety of biomedical research careers.

- The first symposium, held in April 1987, was co-sponsored with the Association of Minority Health Professions Schools (AMHPS) at Meharry Medical College. Using this symposium as a model, AMPHS has sponsored two more symposia with attendance this year of 800-1,000 individuals. NIH has participated in all the symposia and plans to work with AMHPS to co-sponsor a fourth in the fall of 1990.

- Last month, NIH and the Indian Health Service sponsored a symposium in Phoenix, Arizona involving the American Indian and Alaska Native communities. Some 200 high school and undergraduate students and their educators heard lectures by representatives of the Public Health Service, academia, and industry. Reaction to this symposium has been highly favorable, and we have already met with the IHS to plan the next conference for 1990.
- A third symposium, involving the Hispanic community, is being planned for this winter in San Antonio, Texas. At that time, we hope to establish stronger ties with the Hispanic community and stimulate interest among its precollege young people in biomedical research careers.

Regional Meetings on Recruitment of Minorities to Science Careers

Because data indicate that the next generation of scientists will consist largely of minorities and there is a declining interest of minorities in science careers, NIH is also conducting a series of five regional meetings to solicit testimony from the extramural community regarding the nature and scope of programs to attract and support minorities in biomedical science.

Student Curriculum Programs

In late August 1987, the NIH distributed free educational materials to secondary science departments across the country. These materials were designed to accompany a film series to be aired that October, THE HEALTH CENTURY. NIH distributed a companion volume to high school science departments and libraries throughout the country and to high school teacher recipients of the Presidential Award for Excellence in Science and Mathematics Teaching, sponsored by the White House and administered by the National Science Foundation.

Responses from teachers who received the educational materials on THE HEALTH CENTURY indicated a strong interest in the segment on career pathways. Therefore, NIH, in cooperation with nine private sector companies and the New Jersey Business Industry and Science Education Consortium, is developing a new education curriculum, "Health Careers in the Health Century," to present a broad range of health science career options. The program will be tested early next year in New Jersey with the expectation that it will eventually have nationwide distribution.

In addition, NIH and NASA are collaborating in plans to develop an educational program involving students and teachers in the June 1990 Spacelab Life Sciences I mission.

NIH Publications Used in the Schools

Many NIH Institutes publish documents that are used in high schools and colleges. For example, the National Institute of General Medical Sciences has published a series of brochures covering human genetics, cell biology, pharmacology, and structural biology. The most recent brochure, The Structures of Life, was announced in November 1988 through organizations including the National Science Teachers Association. Five thousand of the 10,000 copies printed have been disseminated; 95 percent are being used in schools.

NIH TRAINING AND EDUCATION PROGRAMS

All of the NIH entities participate in government-wide recruitment programs. The Stay-in-School and Summer Aid Programs provide work experience for individuals who need income to remain in school. Many of the students become interested in science by working in the laboratories. Undergraduate students and science majors are employed as laboratory assistants through a variety of employment opportunities.

Most NIH formal training and education programs involving pre-college and undergraduate students target minority groups. These programs include the Minority Access to Research Careers (MARC) Program, which comprises the Honors Undergraduate Research Training Grants and the Faculty Fellowship Awards; the Minority High School Student Research Apprentice Program; the Minority Biomedical Research Support Program; and the Research Grant Supplements for Minority Undergraduate Students.

Under the Honors Undergraduate Research Training Program, administered by the National Institute of General Medical Sciences, 56 minority institutions are receiving support. A congressionally established Task Force on Women, Minorities, and the Handicapped in Science and Technology stated that "of the Federal programs established to give minorities and women access to science and engineering, we found the MARC closest to what we need today . . . a prime example of a successful Federal intervention program." Other organizations--including the National Science Foundation, the Departments of Energy and Agriculture, and the Sloan Kettering Foundation--are establishing programs in the physical sciences and engineering modeled after MARC.

The MARC Faculty Fellowship Award provides opportunities to strengthen research and teaching programs in the biomedical sciences for students of colleges whose enrollments are drawn substantially from minority groups.

The Minority High School Student Research Apprentice Program, administered by the Division of Research Resources, gives minority teenagers the opportunity to work with biomedical investigators who are committed to broadening their scientific understanding and teaching needed skills.

The academic institutions themselves have come to realize the value of this program in providing students for their own graduate and health professional schools and have matched NIH funds with institutional contributions. Since 1980, when it was established as a Presidential initiative, the program has funded 6,954 summer apprentices.

The Minority Biomedical Research Support (MBRS) Program grant supports a program administrator, student research assistants, and groups of individual research projects at each participating institution. The funds permit faculty members, who frequently have prohibitively heavy teaching loads, to allocate more of their time to research. Students are given the opportunity to do actual research.

The MBRS Undergraduate Grant enhances research capabilities at 2-year and 4-year colleges that have not been able to secure the resources necessary to support scientific research. The awards are used to support pilot projects, develop research skills, and sponsor other activities to expand faculty and student research capabilities.

The MBRS Program has provided resources for over 90 minority institutions to engage in biomedical research and to update their science curricula. Close to 16,000 students have been involved in research to date and about 80 percent of these are in the pipeline as potential biomedical researchers.

Our newest program, the Research Grant Supplements for Minority Undergraduate Students provides an opportunity for principal investigators of NIH-supported research project grants to hire minority undergraduate students to conduct research in their laboratories for three months, apart from any academic program or affiliation.

Other training programs and efforts to stimulate interest in biomedical science are sponsored by several of the Institutes:

- The National Cancer Institute sponsors each year a Student Research Training Program that provides training and on-the-job work experience to approximately 90 highly motivated high school and undergraduate students interested in biomedical research.

- The National Institute of Dental Research conducts outreach activities to encourage junior and senior high school students to consider careers in science. Each year these activities reach over 300 students in four local area high schools.
- The National Institute of Neurological Disorders and Stroke, through its Outreach Program, provides students with seminars and workshops to familiarize them with the Institute's intramural and extramural programs. The NINDS Summer Program in Neurosciences gives 20-23 academically talented high school and college students a unique opportunity to gain hands-on research training in NINDS laboratories.
- The National Institute of Diabetes and Digestive and Kidney Diseases supports, each year, the attendance of 10 minority undergraduates at national scientific meetings and provides expanded training opportunities for another 25 outstanding students.
- The National Institute of Allergy and Infectious Diseases has developed a program, "Introduction to Biomedical Research," that annually brings approximately 50 academically talented students from underrepresented minority groups to NIH to learn about career opportunities in biomedical research, particularly within its intramural program.

NIH estimates that it will spend almost $50 million in fiscal year 1989 on its educational initiatives and programs, some of which I have described.

NIH, together with its "Partners in Discovery," recognizes the importance of a strong educational system, capable of rejuvenating and supporting teaching of the basic sciences. The framework of scientific thought begins early. If the system is not strong at the beginning, the desired outcome will not be reached.

Biomedical research has never held greater promise for improving the health of the American people. To achieve that promise, NIH will continue to support the development of scientists who have the technical expertise, the theoretical grasp, and the long-range commitment to solving the mysteries of human biology in an environment of stable support. NIH's mandate and resources require us to concentrate on support for advanced education and training so that our investigators can maintain U.S. preeminence in the biomedical sciences. However, we are dependent on the elementary, high school, and college educational systems; we hope that our modest attempts to reach students at these levels will help our Nation address the serious problem of science education and perhaps serve as models for other programs. We join you in exploring new and innovative ways to address the problems we are discussing today.

Thank you, Mr. Chairman. I would be pleased to answer any questions you may have.

The CHAIRMAN. I thank you, Dr. Wyngaarden.

The Chair recognizes the distinguished Secretary, Dr. Charles E. Hess.

Dr. HESS. Mr. Chairman, I am pleased to appear before you and the members of the Committee to discuss the activities of the U.S. Department of Agriculture that relate to science and mathematics education.

I am pleased to have with me today Dr. Alvin Young, Director of the Department's Office of Agricultural Biotechnology, since he works in an area that is greatly impacted by our topic today.

I am particularly pleased, in my new role as the USDA Assistant Secretary for Science and Education, that my first invitation is to appear before the U.S. Congress is with regard to the subject to which I have devoted a major portion of my career. And also I'm very pleased to have been invited to appear before this Committee.

The U.S. Department of Agriculture firmly believes that a strong program in science and technology is essential to the health of our nation, essential to the quality of life, the economic stability and to national security.

Having said that, I am concerned that the U.S. is losing its edge in the training and educating of scientific and professional personnel. As in other areas of the nation's wellbeing, this trend will have serious consequences to our nation's food and agricultural system.

The future Agricultural research agenda is absolutely dependent on an outstanding cadre of food and agricultural scientists. Regrettably, the growth and development of this scientific expertise base is currently impeded by a variety of factors: declining enrollments, about 30 percent at the bachelor level since—baccalaureate level since 1978: less desirable student academic quality; erosion of the quality of the infrastructure undergirding higher education, as evidenced by dated curricula; an aging faculty; and obsolete scientific instrumentation.

In essence, the higher education system—which is the major producer of the scientists, technicians, educators and entrepreneurs for the nation's food and agricultural system—must be revitalized.

What is the U.S. Department of Agriculture doing in regard to this concern? It has undertaken a broad array of initiatives to advance the training of scientists and professionals. At this time I'd like to highlight a few of the more successful ones.

In 1984 the Department sponsored the first Secretary's Challenge Forum on Investing in Brainpower: Keeping U.S. Agriculture's Competitive Edge. Two major problems identified at the forum were the lack of adequate science preparation for college entrance on the part of American youth and the lack of awareness of career opportunities for scientists and professionals in the food and agricultural system.

Convinced of the validity of these problems, the Department subsequently matched private sector funds to engage the American College Testing Program to undertake a national marketing study to determine the reasons for the declining interest of high school students in agricultural science or business as a college major or future career. We very much look forward to receiving the results of this study within the next few months. We are confident that the findings emanating from the study will be extremely valuable in our efforts to reverse declining college and university enrollments.

We have established a National Research Apprenticeship Program. This program enables science-oriented high school youth to gain summer work experience in university or federal laboratories. To date it has involved approximately 4000 potential young scientists. The Department's $500,000 annual investment has generated substantial additional nonfederal support.

Similarly, the Agricultural Research Service Youth Enrichment Program provides a hands-on science experience for high school sophomores, juniors and seniors in the mid- Atlantic states who are interested in science careers and plan to pursue college.

The Department established an innovative program known as Ag-in-the-Classroom. This program is targeted at grades K through 12. Today it involves volunteers and professional staff working in almost every state in the nation to encourage and assist educators in teaching students about sources of food and fiber and about the role our agricultural science system plays in undergirding our economy and society.

I think it's critically important that we have an agricultural literacy to deal with some of the challenging problems that our society is facing with regard to food safety, water quality and related environmental issues.

Capitalizing on the unique opportunities for reaching sizeable numbers of young people through Extension 4-H programs, we have been moving aggressively to expand science through the 4-H curriculum. A national evaluation of this initiative culminated in a recently released report entitled "Science and Technology, The 4-H Way." This report indicates that we are making good progress and today more than seven million 4-H youth are working on biological, physical and social science projects.

In focusing on precollege activities specifically targeted to the high school level, we have supported three other initiatives of which we are genuinely proud. Along with the Department of Education, we cosponsored a study by the National Academy of Sciences to identify alternatives for enhancing the quality of agricultural science and business education at the secondary level.

We have joined with industry to support the Council for Agricultural Science and Technology in preparing and disseminating a special quarterly publication for high school science teachers and students. Entitled *Science of Food and Agriculture*, this magazine is distributed regularly to some 16,000 high school science departments and individual teachers across the nation. It includes what we believe to be an exciting array of student projects in such areas as biotechnology, water quality and food science.

In the third effort we have provided funding to produce two volumes of science project workbooks to enrich science education. These workbooks have been distributed to high school science teachers in all 50 states.

I would also like to highlight just a few of the special initiatives we have undertaken to enhance the quality of undergraduate degree programs in the food and agricultural sciences.

Since 1982 our Office of Higher Education Programs have supported a number of high priority projects to recommend and implement curricular change in colleges of agriculture and natural resources. These efforts have been successful in several areas, including a systems approach to problem solving, ethics and public policy issues, agri-business management and marketing, and an assessment of the quality of forestry education.

Many changes now occurring across the nation in colleges of agriculture and schools of forestry can be attributed directly to these particular projects, and it's anticipated that many aspects of these projects will continue in the future.

In fact, a new national initiative is being undertaken as the second phase of this process. Known as Project Interact, it involves identifying inventive ways to package curriculum to better serve the needs of non-traditional students in developing alternative instructional delivery systems.

What about the future? We have proposed three competitive grants programs in our FY 1990 budget.

First, we have requested three million dollars for the highly successful Food and Agricultural Science National Needs Graduate Fellowships Program which recruits and trains doctoral and master's fellows in fields identified as having critical shortages of expertise.

Second is an Institution Challenge Grants Program, for which two million dollars is requested, is intended to revitalize the educational system primarily responsible for training food and agricultural scientists and professionals.

And third is a Capacity Building Grants Program, for which we are seeking $11 million, will strengthen the 1890 land-grant universities and institutions and Tuskegee University in such areas as faculty and curricula development, instructional delivery systems, experiential learning, and career access opportunities to enhance the ethnic diversity of the nation's workforce.

The Department is confident that this three-fold approach will make a significant contribution to training the food and agricultural scientists and professionals so sorely needed by the nation.

In summary, the USDA is supporting a multitude of programs across a broad span of levels of education. Because the large majority of these programs involve complementary state and private sector support, as well as volunteer leadership and service, evaluation of the program effectiveness is complex. However there are certain questions which we always endeavor to address in evaluating the results, and these include:

Does a program respond in a cost effective manner to the high priority need as identified by the Department and its cooperators?

Are partnership opportunities utilized to maximum advantage?

Does the momentum of the effort continue beyond direct federal involvement?

And, finally, do the results contribute to the long term solution versus a quick but temporary solution?

I do thank you very much for this opportunity to express our views and concerns. We are fully committed to advancing the frontiers of agricultural science and to maintaining the intellectual capital essential to this endeavor. Please be assured that we are eager to support this Committee in enhancing science and mathematics education, and look forward to cooperating with the other agencies with similar goals.

This concludes my remarks, Mr. Chairman.

[The prepared statement of Dr. Hess follows:]

Statement by Dr. Charles E. Hess
Assistant Secretary for Science and Education
United States Department of Agriculture
Before the
Committee on Science, Space and Technology
House of Representatives
May 24, 1989

Mr. Chairman, I am pleased to appear before you and the Members of this Committee to discuss activities of the U.S. Department of Agriculture (USDA) that relate to science and mathematics education. I am particularly pleased that in my new role as USDA Assistant Secretary for Science and Education my first invitation to testify before the U.S. Congress is with regard to the subject that witnesses have been asked to address today. For, a major portion of my career has been devoted to the furtherance of basic agricultural research and the nurturance of the scientific and professional talent on which this research system is based.

The U.S. Department of Agriculture firmly believes that the advancement of science and technology is essential to the health of every nation--essential to quality of life, economic stability, and national security. Furthermore, we recognize that human resources are key to advancing science and technology. We are concerned that the U.S. seems to be losing its edge in the cultivation of scientific and professional personnel and are especially alarmed about the potential consequences of this trend for our Nation's food and agricultural system.

There is probably no American whose life has not been made better in some way by an agricultural research accomplishment. And the future agricultural research agenda promises to make our lives even better. Yet, the conduct of this agenda is absolutely dependent on an outstanding cadre of food and agricultural scientists. Regrettably, this scientific expertise base can no longer be taken for granted. The training of food and agricultural scientists and professionals is currently impeded by a variety of factors. These include precipitously declining enrollments (30 percent at the baccalaureate level since 1978), less than desirable student academic quality (SAT, ACT, and GRE scores among the lowest of all disciplines), and erosion of the quality of the infrastructure undergirding higher education in the food and agricultural sciences as evidenced by dated curricula, an aging faculty, obsolete scientific instrumentation, and so forth. In essence, the higher education system which is the major producer of the scientists, technicians, educators, and entrepreneurs for the Nation's food and agricultural system must be revitalized.

Since the 1977 Farm Bill designated USDA as the lead Federal agency for higher education in the food and agricultural sciences, the Department has moved in an unprecedented manner to implement policies and programs to respond to this national need. It has undertaken a broad array of initiatives to advance the training of scientists and professionals. The very crux of many of these initiatives has been that of strengthening science and mathematics education at elementary and secondary school levels as well as in college and university programs. While these initiatives have been carried out with very modest USDA support, they have generated substantial State and private sector support and are proving to be an important part of the solution to the problem. At this time, I would like to highlight some of the more successful ones.

In 1984, the Department sponsored the first Secretary's Challenge Forum on "Investing in Brainpower: Keeping U.S. Agriculture's Competitive Edge." Cosponsored with the National Academy of Sciences Board on Agriculture, the Forum brought together leaders from business, government, and academia to discuss problems impacting the training of the Nation's food and agricultural scientific and professional workforce. Two major problems identified at the Forum were the lack of adequate science preparation for college entrance on the part of American youth and the lack of awareness of career opportunities for scientists and professionals in the food and agricultural system. Convinced of the validity of these problems, the Department subsequently matched private sector funds to engage the American College Testing Program to undertake a national marketing study to determine reasons for the declining interest of high school students in agricultural science or business as a college major or future career. We very much look forward to receiving the results of this study within the next few months. We are confident that the findings emanating from the study will be extremely valuable in our efforts to reverse declining college and university enrollments.

In order to network promising students into the food and agricultural sciences, we established a National Research Apprenticeship Program in 1979. This program enables science-oriented high school youth to gain summer work experience in university or Federal laboratories. It is strongly directed toward minority and female youth and has to date involved approximately 4,000 potential young scientists. USDA's $500,000 annual investment has generated substantial additional nonfederal support. Similarly, the Agricultural Research Service Youth Enrichment Program provides a hands-on science experience for high school sophomores, juniors, and seniors in the mid-Atlantic States who are interested in science careers and plan to pursue college. This program is specifically aimed at familiarizing students with agricultural science career options and developing leadership skills through summer learning experiences. As such, the program includes lectures, tours, and career seminars. The Department has also instituted a program whereby specific agencies adopt and work directly with a high school or middle school by providing advice and assistance in the development of educational programs, including student career information and occupational counseling. Particular instances of this initiative can be seen at the Saul High School in Philadelphia and the Chicago High School for Agricultural Sciences.

Recognizing the need to promote science literacy at all levels of schooling, the Department established a highly innovative program in the early 1980's. Known as Ag-in-the-Classroom, this program is targeted at grades K-12. Today, it involves volunteers and professional staff working in almost every State in the Nation to encourage and assist educators in teaching students about sources of food and fiber and about the role our agricultural science system plays in undergirding our economy and society. It emphasizes the integration of information about food and agriculture into subjects already being taught, particularly science and mathematics. States are responsible for funding, teacher training, and materials development with USDA serving as the national coordinator, clearinghouse, and distributor of program materials. USDA Ag-in-the-Classroom personnel recently produced a video entitled "21st Century Explorers" which introduces junior high school students to the world of agricultural science and technology and affords them a glimpse of the exciting careers available to food and agricultural scientists. Current funding for this program is about $150,000 annually.

Capitalizing on the unique opportunities for reaching sizeable numbers of young people through Extension 4-H programs, we have been moving aggressively to expand science throughout the 4-H curriculum. A national evaluation of this initiative culminated in a recently released report entitled "Science and Technology: The 4-H Way." We are excited that today, according to this report, biological sciences underlie 55 percent of 4-H projects, physical sciences form the basis of 10 percent, and social sciences the core of an additional 23 percent. Thus, these three areas of science are being emphasized in 88 percent of all 4-H projects and are reaching more than 7 million youth. In an effort to further capitalize on the opportunity to interest youth in science through 4-H programs, the Department has been working in concert with university faculty to develop a mentors-in-science program to help youth develop positive attitudes toward the sciences. Another partnership venture involves Extension 4-H and NASA and has resulted in a television series entitled "Blue Sky Below My Feet." This innovative series helps youth explore space technology and how it relates to life on earth by focusing on "Foods," "Fibers," and "Forces." The video series, which was shown to more than 126,000 youth in 28 states last year, includes manuals for participants and instructors and a wide array of supplemental hands-on learning activities.

In focusing on precollege activities specifically targeted to the high school level, we have supported three initiatives of which we are genuinely proud. Along with the Department of Education, we cosponsored a study by the National Academy of Sciences to identify alternatives for enhancing the quality of agricultural science and business education at the secondary level. This study culminated in a widely acclaimed report released via a national interactive video conference involving secondary teachers, teacher educators, and public policy officials. As a result, significant curricula changes are now underway in several States and a few States, namely Texas, Utah, and California, have replaced vocational agriculture with agricultural science in their high school programs.

For the past six years, we have joined with industry to support the Council for Agricultural Science and Technology in preparing and disseminating a special quarterly publication for high school science teachers and students. Entitled "Science of Food and Agriculture," this magazine is distributed regularly to some 16,000 high school science departments and individual teachers. It includes study materials, student projects, and career information relative to emerging areas of food and agricultural science such as biotechnology, environmental degradation, water quality, and food safety.

In a third effort, we have provided funding to produce two volumes of science project workbooks to enrich science education. These workbooks have been distributed to high school science teachers across the Nation. The Department has been commended for this effort, and these publications remain in high demand.

We appreciate the fact that the challenge of ensuring an adequate base of scientific and professional expertise in the food and agricultural sciences will require new and bold initiatives. Hence, we have proposed three competitive grants programs in our FY 1990 budget. We have requested three million dollars for the highly successful Food and Agricultural Sciences National Needs Graduate Fellowships Program which recruits and trains doctoral and master's fellows in fields identified as having critical shortages of expertise. Initiated in 1984, the program has served to attract superior new graduate students from a broad array of academic backgrounds. The average Graduate Record Examination score of the 418 fellows supported by the program to date is almost 1,300, more than 300 points higher than that of the average graduate student in agriculture. The quality of scientific expertise emanating from this program is proving to be outstanding and strongly attests to the value of a cooperative partnership between the higher education system, the U.S. Department of Agriculture, and the Congress. An Institution Challenge Grants Program, for which two million dollars are requested, is intended to revitalize the educational system primarily responsible for training food and agricultural scientists and professionals. Likewise, a Capacity Building Grants Program, for which we are seeking eleven million dollars, will strengthen the 1890 land-grant institutions and Tuskegee University in such areas as faculty and curricula development, instructional delivery systems, experiential learning, and career access opportunities to enhance the ethnic diversity of the Nation's workforce. Matching from non-Federal sources will be a requirement for the challenge grants and capacity building programs which benefit the participating institutions and the agricultural education sector as a whole. Matching will encourage more active participation of a variety of private, public and non-profit organizations and will increase the total resources available to meet the critical needs I have mentioned. The Department is confident that this three-fold approach will make a significant contribution to training the food and agricultural scientists and professionals so sorely needed by the Nation.

We hope the foregoing provides you with ample evidence of the high priority we attribute to science and mathematics education. As you can see, we are supporting a multitude of programs across a broad span of levels of education. Because the large majority of these programs involve complementary State and private sector support as well as volunteer leadership and service, evaluation of program effectiveness is indeed complex. Nevertheless, there are certain questions which we always endeavor to address in evaluating programs and results. These include: Does the program respond in a cost effective manner to a high priority need as identified by the Department and its cooperators? Are partnership opportunities utilized to maximum advantage? Does the momentum of the effort continue beyond direct Federal involvement? Do the results contribute to a long-term solution versus a quick but temporary solution? In seeking answers to these questions, we often utilize experts from academia, business, and other Federal agencies to complement the efforts of in-house staff. We closely monitor continuing demand for final products such as printed materials and video tapes. For initiatives involving student applications, we maintain appropriate data bases to analyze changes in demand. For public information initiatives, special attention is given to the number and content of written and oral inquiries. Ultimately, we integrate these criteria and these approaches to determine program effectiveness. In the future, we certainly will be watching closely for quantitative indices that our universities are recruiting and producing sufficient numbers of graduates at the forefront of science and technology. Our programs are young, however, and a final judgment on our progress in this direction would be somewhat premature at this time.

In terms of promoting dissemination and utilization of program results, we believe that we employ several effective strategies and mechanisms. For example, we have yet to undertake an initiative in science and mathematics education which is targeted toward resolving a problem that has not surfaced at the national level via a considerable grass roots effort. Furthermore, we strive to involve the cooperators primarily responsible for delineating a problem in both the design and implementation of programs aimed at a solution. This approach, to a certain extent, assures that product demand is built into and heightened throughout the conduct of a program. In addition, we rely heavily on regional and national conferences as well as video teleconferences which are project specific. Our staff are encouraged to present major addresses at a host of national meetings and are provided with requisite travel support. We also maintain a computerized mailing system which enables us to communicate rapidly and frequently with the more than 700 deans of college and university programs in the food and agricultural sciences, the business community, trade associations, and key professional societies.

Chartered by the Congress in 1977, the Joint Council on Food and Agricultural Sciences serves as an important source of advice in planning and coordinating the broad array of USDA science and education initiatives. It is important to note that nurturing the development of scientific and professional expertise consistently has been cited among the top four priorities identified by the Council over the past several years. Also, the Department is an original member of the Federal Interagency Committee on Education, a Congressionally mandated entity whose mission is to coordinate education activities across the Federal government. This Committee is chaired by the Secretary of Education and comprised of policy making officials from some 13 agencies with responsibility for education programs. Our office of Higher Education Programs works extensively with other Federal agencies (particularly the National Science Foundation, the Department of Labor, and the Department of Education) to improve the quality of national education and employment data acquisition and reporting.

Mr. Chairman, I want to thank you for addressing agriculture in the context of these hearings. All too often, the magnificent contributions our food and agricultural scientists have made to this Nation's high standard of living and its economic competitiveness are taken for granted. For, as Andre and Jean Mayer wrote in 1974, "Few scientists think of agriculture as the chief, or the model science. Many, indeed, do not consider it a science at all. Yet it was the first science--The Mother of Sciences; it remains the science which makes life possible, and it may well be that before the century is over the success or failure of science as a whole will be judged by the success or failure of agriculture." The Department is committed to advancing the frontiers of agricultural science and to maintaining the intellectual capital essential to this endeavor. Please be assured that we are eager to support this Committee in enhancing science and mathematics education.

This concludes my prepared remarks, I would be pleased to respond to any questions from the Committee.

The **Chairman**. I thank the gentleman very much.

The Chair now recognizes Dr. John ~~Moore,~~ Deputy Director of the National Science Foundation.

Dr. Moore.

Dr. **Moore**. Thank you, Mr. Chairman. I have a detailed statement that I would like to include in the record.

The **Chairman**. It will be included in the record with no objection. So ordered.

Dr. **Moore**. As you know, the NSF Director is unable to attend the hearing this morning because of unavoidable scheduling conflicts; but, he and I both want to commend you, Mr. Chairman, and the Committee for holding this series of hearings on such a critically important topic. It is truly one of the most important facing our nation.

Mr. Chairman, you set the stage for this hearing this morning when you pointed out that—and here I'm quoting, I think:

> "It is only through technological innovation that we can generate the advances and material wealth that ultimately provide us with the standard of living we must have. If we are to create this technological innovation it must come through new knowledge that can serve as a basis for new products and services. To create that new knowledge we must have a well-educated and well trained scientific and technical work force. That in turn is dependent upon a strategy that extends over our entire educational enterprise, from K through 12 all the way through the post-graduate level."

As this Committee knows, NSF has a dual mission: To strengthen the national capacity for research, as well as education at all levels in science, mathematics and engineering.

In that regard NSF is committed to expanding programming to improve the quality of science and mathematics education for all students. The Foundation also stimulates activities that enhance the scientific literacy of the general population. And we work to support the development of the nation's scientific and technical work force, so we might have the personnel we need to meet the challenges of the future.

The scale and quality of the nation's S&T efforts depend on the supply of highly trained and educated people. But the current prospect is very disturbing, as we know only too well. From the U.S. high school graduating class of four million students, we can expect about 200,000 baccalaureate scientists, engineers and mathematicians, and fewer than 10,000 doctorates.

These figures are below present needs and mean that we will face a serious shortage of technical personnel in the future unless we do a better job of attracting a larger proportion of the student population to science and engineering.

Equally important to the national well-being is the general population scientific literacy. No nation can protect or improve its economic competitiveness if it neglects the scientific literacy of the general population.

Recognizing these points, NSF has made human resources development a top priority in its long range planning. Our programs are designed to improve the scientific understanding of all students and to increase the numbers of young people who pursue science and mathematics.

Our precollege programs represent the largest single component of our education and human resource effort. In the elementary and middle and high schools, the Foundation supports innovative and model-building projects in teacher inservice education and in the preservice education of future teachers.

We also support the development of new, high quality instructional materials, research into the process of teaching and learning, and applications of new technologies for classroom activities.

Support for precollege programs has increased dramatically since 1983. It will total about $129 million in Fiscal Year 1990.

However, our role in precollege education, which focuses exclusively on science and math, is, of course, very small in relation to state, local and other federal support for education. Therefore our role has to be one of providing leadership and stimulating innovation in the schools.

I repeat: It is an effort that spreads across all levels of K through 12 education, elementary, middle school, and high school.

The efforts at the K through 12 level are critical. We may reach full payoff some time around the beginning of the next millennium. But, we also need to attract more of today's college students to scientific and technical careers. That calls for efforts in the undergraduate area.

Our undergraduate activities focus on about four major areas: instrumentation and laboratory improvement, faculty enhancement, projects to improve undergraduate curricula, and projects to provide research experiences to undergraduates.

The undergraduate programs, I would like to note, have been moving very rapidly. We are proposing a 60 percent increase in this area for Fiscal Year 1990, which would lead to a total investment of about $105 million in undergraduate education.

Beyond the undergraduate years our focus on human resources has founded some very well known programs, such as the NSF Graduate Fellowship Program, which I am very, very proud to say this year gave its 25,000th award.

We also provide support for graduate students through research assistanceships. We have a number of programs for postdoctoral scientists and engineers, including the prominent one, the Presidential Young Investigators Program.

Mr. Chairman, I think, in understanding what the National Science Foundation's educational efforts are, it is very important to look at the total effort that is spread across all levels of education, as is our legislative mandate. That effort in Fiscal Year '89, the present year, will in fact total approximately $500 million. And it is important in understanding that figure to compare it to the comparable number of the 1960s.

The total effort today is roughly the same, in fact, as it was in the 1960s in inflation-adjusted dollars, but the distribution is very different.

In the 1960s about 80 percent of our effort was in the Directorate for Science and Engineering Education, or its equivalent, and about 20 percent was in the Research and Related Activities area. Today those are almost reversed. It's about 35 percent in the Directorate for Science and Engineering Education and about 65 percent in the Research and Related Activities Directorate.

I want to say there is a very good reason for this change. The reason is that we believe that education is such an important part—education and support for human resource development is such an important part of what we're doing that it must be spread throughout the Foundation, where the entire resources—including the human resources of the Foundation—can be brought to bear on the problem.

I wanted to interject this point of clarification, Mr. Chairman.

All of our education programs are designed to stimulate the interest of women, minorities and disabled students and to help attract more of them to careers in science and engineering. As has been pointed out this morning, this is critically important because long term trends tell us the important demographic changes are taking place in the United States, and that these changes sharply increase the importance of attracting women and minorities to the sciences and engineering.

In spite of recognition of this fact, I think it's plain to see that current efforts have simply not been enough. Consider this: At its peak in 1976, total minority enrollment at the undergraduate level was about 14 percent of the college population. In 1984 it had fallen to 12 percent.

At the graduate level, the situation is worse. Today blacks and hispanics each earn only about two percent of all science and engineering doctorates. If you confine it to attention of the physical sciences, the situation is even more disturbing. Of the over 4500 Ph.D.s awarded in these disciplines in 1987, 41 were awarded to blacks. Not only is this number low, it is declining, down from about 60 ten years or so ago.

That kind of a trend is alarming, and it is unacceptable. And we have to do much more than we are presently doing to change that.

Turning to a few comments about our partnerships with industry and other federal agencies, we realize that enhancing the quality and effectiveness of science education and engineering education is a challenge that requires broad participation. We have sought to attract the participation of industry and other agencies to help improve the quality of our nation's efforts as well as to leverage our scarce dollars.

For example, our Private Sector Partnership Program encourages industry to invest intellectual capital to improve science education in the elementary and secondary schools.

Our Publisher Initiative requires start-to-finish participation of a private publisher in each of its projects for development of new instructional curricula.

With other state, local and federal entities we are working in a variety of ways. With the Department of Education, we have jointly supported children's television programming such as "3-2-1 Contact" and "the Masters Square One".

And if I may, Mr. Chairman, I would like to mention that on Monday evening an episode of "3-2-1 Contact" received a Peabody Award in New York City, which we are very, very proud to have happened to that particular series.

Together with Secretary Watkins and the Department of Energy, NSF is continuing to work with the national labs to bring students and teachers into those laboratories for a wide range of activities.

What has happened so far in these programs? The vast majority of the individual projects that we support we regard as being fully successful at the institutions where they take place.

For example, virtually all of our Teacher Enhancement Projects do improve the subject matter knowledge of the participants and sharpen their teaching skills. Nearly all Instructional Materials Development projects do generate materials that interest and educate their trial audience better than the materials they replace.

On the other hand, the success of the programs of which the projects are constituent parts is made clear much more slowly and is more difficult to measure.

To use new approaches to teaching, teachers must become familiar with the new materials, be comfortable with their ability to master the new knowledge and be convinced that the students will really benefit from these changes. That requires implementation efforts that are being developed and supported by NSF.

Once they have had a chance to work, then it may be possible to ask the right questions concerning the success of these programs. But we are in the process of designing those questions and those evaluations today.

Overall, Mr. Chairman, the progress achieved thus far provides a sound basis for greater future efforts. The shorter term impacts already mentioned are occurring in the vast majority of projects supported by the Foundation. We are confident that the longer term improvements designed will be realized provided that substantial efforts that are now put on are in fact sustained.

The appropriations provided for the current year and the request pending for Fiscal Year 1990 and the general commitment of the President and the Congress, and in particular this Committee, to better the NSF budget by 1993 go a long way toward providing a stable environment for program planning and development. In that kind of environment, NSF can and will intensify its efforts to meet the challenges and opportunities that we are facing in this critical area.

Thank you. And I will be pleased to answer your questions.

[The prepared statement of Dr. Moore follows:]

TESTIMONY

DR. JOHN H. MOORE

DEPUTY DIRECTOR

NATIONAL SCIENCE FOUNDATION

COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

WASHINGTON, DC

MAY 24, 1989

The Education Role of the National Science Foundation

The NSF has a dual mission. It is charged to improve and strengthen the national capacity for research in mathematics, engineering, and many fields of science; it has a similar charge with respect to excellence and strength in science, mathematics, and engineering education.

The National Science Foundation is working toward a state of excellence in science, engineering, mathematics, and technology education in the United States. This half of the Foundation's dual mission is built upon the premise that education in science, engineering, mathematics, and technology must be available at every educational level in high quality and in forms that stimulate the interests of every student and citizen and permit them to exercise intelligently their powers as citizens in an effective democracy.

The National Science Foundation is committed to:

- Expand programming that will improve the quality of education in mathematics, engineering, and the sciences for all students;
- Stimulate and support educational activities that will enhance the scientific, mathematical and technological literacy of the population; and
- Encourage and support the development of the Nation's scientific and technological human resources -- so that there is a full and steady stream of highly educated scientists, mathematicians, and engineers to participate in the Nation's research and production activities.

Education and Human Resources

The Charter for these Hearings on Science and Mathematics Education speaks forcefully to the serious problems of low student achievement in science and mathematics, and the decline in the number who choose (or who are sufficiently well grounded to choose) to prepare themselves for careers in science, mathematics, technology, and engineering.

The National Science Foundation has placed human resources development at the top of its list of priorities. NSF's education programs address both the qualitative and quantitative deficiencies apparent in the output of the nation's present apparatus for producing well-qualified professionals and a well-informed citizenry.

The Foundation's programs are designed strategically to improve the awareness and understanding of science, mathematics, and technology by all students; to increase the numbers of young people who concentrate their studies on science and engineering;

and to improve the quality of the education they receive. To better educate our students in the sciences, our teacher population needs a better educational base, more recognition of its critical mission, and new entrants to fill future needs. Unless we do a much better job at attracting students and giving them the best possible training, we cannot meet the challenges we face in international competition.

The scale and quality of the nation's science and technology efforts depend ultimately on the adequacy of the supply of highly trained and educated people. The current prospect is not a comforting one: American students have not been pursuing careers in science and engineering in numbers sufficient to meet future needs.

- Less than 20% of high school sophomores are interested in careers in natural sciences or engineering.
- Only 1 in 20 students who go on to college receive baccalaureate degrees in science or engineering.
- Less than a third of those who receive the baccalaureate continue their training; and only a quarter of that group eventually receive doctorates.

Thus, from a U.S. high school graduating class of 4 million students, we can expect in due course only about 200,000 baccalaureate scientists, mathematicians, and engineers, and fewer than 10,000 doctorates. These outputs are below present needs in education and industry. Current trends suggest that demand for scientists and engineers will increase for years to come; yet, the number of college age students is dropping steadily, and we face a potentially serious shortage of technical personnel unless a greater proportion of the student population is attracted to science and engineering.

Equally important to the national well-being is the state of science awareness and what is familiarly called the "science literacy" of the general population. No nation can neglect the science and mathematics content of the education of the vast majority of its citizens who will not pursue careers in those fields or in engineering. The Foundation is committed to development of vigorous and high quality education programs to prepare tomorrow's citizens for the highly technological world in which they will live.

Recent Growth of NSF Education and Human Resources Activities

The National Science Foundation has established programs that address the education and human resources issue in many different ways. There have been dramatic increases in support for education at all levels and efforts to broaden participation of underrepresented groups, such as women and minorities; and underrepresented institutions, such as undergraduate and community colleges and minority institutions. Support for education and human resources has grown from about 3% of the NSF budget in 1982 to over 15% in 1989, and is over 16% of the NSF's FY1990 Budget Request. Another tangible result of these efforts is that the numbers of people -- students at all levels, teachers and research faculty, and investigators -- supported under NSF programs, have more than doubled over that period.

NSF Priorities and Education Programs

Since the Foundation cannot accomplish everything with the resources likely to be made available, choices must be made. Within NSF there is a continuing need to set priorities among many competing initiatives of importance and high merit. This is no different in principle from the problem faced by the Congress as it considers programs across all areas of national responsibility.

Planning for the Foundation's educational activities involves information, advice, and expertise from the broad community of scientists and educators from both public and private institutions, educational administrators, and officials of government. The work takes into account national goals; the state and health of science, mathematics, and engineering education at all levels; needs and opportunities; and many other factors.

The Foundation reports annually to the Congress on its forward planning in Science, Mathematics, and Engineering Education. A copy of the December 1988 Strategic Plan (for FY1989-FY1993) is attached to this document as an appendix.

For many years, the Foundation's first priority has been people -- in its programming for both education and research. Implementation of this priority takes different forms at each level of education.

The Foundation's precollege programs are the largest component of its education and human resources effort.

- At the elementary/middle school level, an emphasis on people means concentrating on the scope, scale, and quality of the science and mathematics instruction received by all students, not just those with affection or talent for science or mathematics. NSF supports innovative and model-building projects in teacher inservice education and in the preservice education of future teachers; the development of new, high quality instructional materials; research on the process of teaching and learning and on the applications of advanced technologies to classroom activities.

- High school level projects embrace all of the kinds just described, but include in addition many that address two kinds of special needs: (1) those of young persons who have formed a strong identification with science, mathematics, or engineering -- the future practitioners in those areas; and (2) those of young people who will have little or no contact with science or mathematics instruction after they graduate from high school -- the students who constitute the vast majority of tomorrow's citizens.

Support for precollege activities has increased dramatically since 1983. Nevertheless, the NSF role in precollege education is very small in relation to state and other Federal support for education, and focuses only on science and mathematics. The Foundation can lead and it can stimulate others to lead and to innovate; but the States - which have the principal obligation for education - must step forward with renewed efforts. NSF will continue to encourage partnerships among the state, local, and private players concerned with responsibilities in these areas.

Precollege science and mathematics education has a potentially large impact on the long-term prospects for the recruitment and retention of scientists and engineers. While today's efforts in the schools will reach full payoff by the year 2000, we must attract more of today's university and college students to such careers as soon as possible; improved undergraduate education in science, mathematics, and engineering promises that result.

- The Foundation's undergraduate activities are designed to enhance the quality of instruction through several kinds of support: purchases of instrumentation to improve laboratory instruction; faculty enhancement activities; projects to improve courses and curricula -- for students preparing for both technical and non-technical careers. For the former, a variety of research-centered programs are in place in addition to those that are instruction-centered.

The Foundation's comprehensive set of undergraduate programs engages all of the directorates. Some programs are funded and managed entirely in the Research Directorates, some in the Directorate for Science and Engineering Education (SEE). All of the undergraduate activities are coordinated by SEE's Division of Undergraduate Science, Engineering, and Mathematics Education (USEME).

Above the undergraduate level, the Foundation's educational programming is devoted entirely to development of human resources for the nation's critical research activities.

- A trio of graduate level fellowship programs provide direct support to nearly 2000 of the Nation's most able young people who are preparing for research careers in science, mathematics, and engineering. NSF's research grants support an additional 12-thousand graduate students in engaged in advanced study in a broad spectrum of science, mathematics, and engineering fields.

- At the postdoctoral level, the Foundation is helping to meet the intense national need for highly educated university and college teachers through several programs designed for young investigators -- on whom the future quality of university and college faculties depends.

Cross-Program Efforts to Correct Underrepresentation

A feature of all these programs is that they are designed and structured to stimulate the interest of women, minority, and disabled students in science and mathematics. The Foundation's programs help them to keep open their educational options so that they do not prematurely or unwittingly close off those aspects of their precollege education that would prepare them to act on late-blooming determination to prepare for careers in science, mathematics, or engineering.

In addition to this general emphasis, NSF has in place a number of programs more specifically oriented toward this objective; one concentrates on students in the middle school and high school years; another is designed to strengthen minority outreach activities spanning the transition years between high school and college.

Attracting and retaining minorities and women in science and engineering means overcoming special and longstanding problems. Yet, changing demographics indicate that underrepresented minorities and women will make up a much larger proportion of student populations and new workforce entrants in the next twenty years than today. It is essential to look to all segments of our population for the scientists and engineers we need.

NSF Relationships to Industry and to Other Federal Agencies

Industrial participation in the Foundation's programs is sought and secured for every educational level because of the important intellectual and fiscal resources it can bring to bear on the solution of local education problems. Industrial participation requires new working relationships, but it can help meet special needs, hasten progress, and improve focus on common interests. For example:

- The Private Sector Partnerships program (within the Science and Mathematics Education Networks Program) encourages business and industry to invest some of their intellectual capital in efforts to improve science and mathematics education in local and regional elementary and secondary schools.

- Corporate support of National Science and Technology Week grew from 4 sponsors contributing $100,000 in 1984 to 15 sponsors contributing almost $500,000 in 1989. NSTW is a "grass roots" activity with many industrial participants that reaches tens of thousands of students, teachers, and parents; it is an effective stimulus to learning about science and technology.

- The Foundation's "Publisher Initiative" requires the start-to-finish participation of a private publisher in each of its projects for development of new science and mathematics curricula and instructional materials for schools.

- The "at least equal match" provision of the College Science Instrumentation Program is met more often by industry than by any other kind of funds source, and industry is the most frequent source of more-than-100%-matching.

- Industry participation is a feature of the undergraduate and graduate educational programming built into each of the Engineering Research Centers. And,

- The young college and university faculty members who are recipients of the Foundation's coveted Presidential Young Investigator awards secure millions of dollars a year in matching support from industrial sponsors interested in the kinds of research they do.

The Foundation seeks similar collaboration with other levels of government and with other Federal agencies:

- Conversations are on-going with the National Governors Association, individual governors, and state administrators to encourage increased linkages between NSF and state-financed programs.

- The Foundation is actively expanding long-standing cooperation with the Department of Education and looking for ways to act on the President's commitment to education:

  We have jointly supported children's television programming, such as "3-2-1, Contact!!!"; various national education assessment efforts, such as the National Assessment of Educational Progress; and related demographic studies.

  The Foundation has also worked with the Department to assure that States can use DoEd block grant funds to support teachers who win places in NSF-supported inservice teacher institutes.

- NSF is developing a significant collaboration with the Department of Energy to encourage and support that Department's program to bring students and teachers into certain of the National Laboratories for activities ranging from guided tours at every age level to participation in research by teachers and advanced students.
- The Foundation is developing arrangements with the National Aeronautics and Space Administration to assure appropriate interaction and desirable synergism of the educational programs of both agencies.
- The Foundation is an active participant in the efforts of the working groups and task forces of the Economic Policy Council to improve and increase interagency coordination.
- Finally, the NSF is a member of the Interagency Commission on the International Space Year which is working to develop both the research and educational activities that will constitute that long event.

NSF Education Programs

A. Precollege Level

The teacher is critical to the quality and effectiveness of education in every field. NSF supports experimental and model-building programs for pre-service [Teacher Preparation Program] and for in-service [Teacher Enhancement Program] improvement of teacher capabilities -- in both subject-matter and pedagogy. Networking leader teachers to others [Science and Mathematics Education Networks Program] provides powerful leverage of these efforts. And, the Foundation and the President recognize the Nation's master teachers [Presidential Awards in Science and Mathematics Teaching].

Good teachers need improved instructional materials [Instructional Materials Development Program]; their work is made more effective when television and radio programming, and the activities of science museums and science clubs can be coordinated with what goes on in the class room [Informal Science Education Program]. Running fast so as not to fall behind means that NSF supports work on educational applications of new technologies -- calculators, computers, and interactive videodiscs [Applications of Advanced Technologies Program].

The Foundation supports many projects that focus on talented secondary school students [Young Scholars Program] (especially members of underrepresented groups), stimulating their interest in mathematics, science, and engineering, and helping them maintain options.

Important guidance for these precollege activities comes from the findings of research on the process of educating [Research in Teaching and Learning Program]; from the collection and analysis of data on science and engineering education issues, and support of related policy studies and policy development [Studies and Analyses Program]; and from NSF's continuing effort to improve its own education activities, and to provide information for planning to colleges, universities, and governments at all levels [Assessment Studies].

The Foundation's FY1989 appropriation allocates $119 million to the support of these precollege education programs. [The FY1990 Budget Request includes $129 million for these programs.]

B. Undergraduate Level

The National Science Board report "Undergraduate Science, Mathematics and Engineering Education (NSB 86-100)," identified five major entry points where action by the Foundation could have maximum coherence and leverage with respect to research and education at the undergraduate level: students, instrumentation and laboratory improvement, faculty, curriculum, and other special focused programs. The programs devised to address the major needs at this educational level are in two closely-related groups:

(1) The undergraduate research-centered programs extend to that educational level kinds of activities with which the Foundation has long and successful experience. In FY1989, the Foundation's Research Directorates will expend an estimated $37 million on: the Research Experiences for Undergraduates Program, providing opportunities for hands-on student research experience; Research in Undergraduate Institutions grants and Research Opportunity Awards, coupling research and education in undergraduate academic departments through the support of faculty research; awards to institutions for scholarship and enrichment programs for minority students in science and engineering, through the Research Careers for Minority Scholars program; and on a portion of other Faculty Enhancement and Course/Curriculum projects. [These expenditures would be $70.4 million under the FY1990 Budget Request.]

(2) The undergraduate instruction-centered programs are newer, but have an even wider compass. Twenty-eight million dollars was appropriated in FY1989 to NSF's Directorate for Science and Engineering Education (SEE) for its share of: the Instrumentation and Laboratory Improvement Program, which develops new approaches to improving the effectiveness and efficiency of laboratory instruction through the use of modern instrumentation; the Faculty Enhancement Program, to improve the disciplinary capabilities and teaching skills of faculty members; the Courses and Curricula Program, to support the creation of more effective

undergraduate courses and curricula; and the Career Access Program, which is designed to increase opportunities in science and technology for women, minorities, and the disabled. [The FY1990 Budget Request contains $30 million for these purposes.]

C. Graduate Level and Beyond

SEE's principal research career development activities are the Graduate Fellowship Program and the Minority Graduate Fellowship Program. Through this prestigious pair of programs, a core group of outstanding graduate students is identified and provided extended support for advanced education. In FY1990 there will be a new program of fellowships -- "Women in Engineering," targeted on one of the most serious under-representations to be found today in the technical professions. The several fellowship programs make an important contribution to the support of the Nation's top graduate students. During FY1989, new awards will be made to 860 individuals, and a total of 1950 fellows will be on tenure; $23 million was appropriated to SEE for these purposes in FY1989 [and $31 million has been requested for FY1990].

Over twelve thousand graduate research assistantships are supported by the Foundation through the regular research grants programs. These grant programs cover a broad spectrum of research fields, including the many kinds of engineering; the mathematical, computer, and information sciences; and the whole family of NSF physical, biological, and behavioral sciences. The value of this support to graduate education from the Research & Related Activities Account is estimated to be $142 million in FY1989 [$160 million in FY1990].

There are three major components to the Foundation's postdoctoral educational activities. The NATO Postdoctoral Fellowships in Science Program, through which outstanding recent recipients are enabled to study at overseas research sites, is administered by NSF but funded by NATO.

The Presidential Young Investigators Program is the young faculty component of NSF's research support activities. Through it, outstanding young scientists, mathematicians, and engineers are helped to initiate and maintain the research activities that are expected of those in tenure-track faculty positions. Other formal postdoctoral programs are supported in several of the Research Directorates; in addition, a substantial number of postdoctoral scientists are appointed each year under regular research grants. For FY1989, it is estimated that 3800 postdoctorals were supported, at a cost of $68 million. [For FY1990, the corresponding figures are 4000 postdoctorals at a cost of $75 million.]

Results to Date

The vast majority of completed projects supported by the Foundation are fully successful at the originating institutions. The measures of success depend on the nature of the project, but are negotiated and built-in before awards are made. For example:

> Virtually all Teacher Enhancement projects DO improve the subject-matter knowledge of their participants and sharpen their pedagogical skills. Virtually all Instructional Materials Development projects DO generate materials that interest, stimulate, and inform their trial audience better than the older materials they replace. Virtually all College Science Instrumentation projects DO improve an important undergraduate laboratory course. Virtually all individuals who are awarded Graduate Research Fellowships DO go into academic or industrial research careers. And, virtually all Presidential Young Investigators DO resist the blandishments of industry to remain in college and university faculty positions.

But, the success of the programs that support large numbers of individual projects is made manifest much more slowly and is much more difficult to measure. Further, the success of a program may depend upon the transfer of locally-gained project experience to other institutions -- and that transfer is very difficult to secure:

> There is understandable local reluctance to implement new curricula and instructional techniques when those currently in use are regarded as serviceable though not ideal. To secure adoption and utilization of new approaches to instruction, teachers must be helped to become familiar with the new materials, to feel confident of their own ability to master the new knowledge, and to be sure that the students will really benefit from the changes to be made.

The achievement of success in such a program requires new, multi-faceted implementation efforts; the Foundation is planning and supporting such efforts in order to assure that its investments have the broad payout expected of them. Then, it may be possible to ask the right questions about longer-term, wider-reach program success:

> Are students taught by participants in Teacher Enhancement projects more knowledgeable in science and mathematics; and do more of them choose to prepare themselves for technical careers? Do the texts, modules, courses, and curricula resulting from Instructional Materials Development projects lead to more effective and more stimulating teaching and learning; and are they adopted widely outside the "test-bed" institutions or school districts? Are the improvements in

undergraduate laboratory courses made possible by the College Science Instrumentation projects adopted by other colleges and universities; and do they stimulate other curricular changes? Do the scientists who held Graduate Research Fellowships have longer, more productive, and more creative research careers than those who did not? And, do the faculty members who were Presidential Young Investigators become inspiring teachers of the next generations of scientists and engineers?

Overall, the progress achieved thus far in the comprehensive educational programs of the National Science Foundation is clearly commensurate with the investment that has been made and provides a sound basis for greater future efforts. The shorter-term impacts mentioned above are occurring in the vast majority of projects funded by the Foundation. Other positive signs are to be found in observations such as: the numbers of proposals submitted increases each year more rapidly than the resources available to fund them; a broader spectrum of institutions submits proposals; demands for participation in teacher and faculty enhancement projects increase steadily; etc.

The Foundation is confident that the longer-term impacts desired and expected by all will be realized also, provided substantial and sustained efforts are made. The commitment by the Congress in the FY1989 Appropriation Act, the position of the President in the FY1990 Budget Request, and the concurrence by them both in the determination to double the Foundation's budget by 1993, go a long way toward providing a stable environment for planning NSF's research and education activities. Given that environment, the National Science Foundation can intensify its efforts to meet the challenges and opportunities of greatest significance to the Nation.

APPENDIX

December 14, 1988

ENHANCING THE QUALITY
OF
SCIENCE, MATHEMATICS, AND ENGINEERING EDUCATION
IN
THE UNITED STATES

STRATEGIC PLAN FOR FY1989 - FY1993

NATIONAL SCIENCE FOUNDATION

TABLE OF CONTENTS

Preface iii

INTRODUCTION 1

1. Role of the National Science Foundation in Education . 1
2. The Directorate for Science and Engineering Education 4
3. Goals of the Directorate for Science and Engineering Education 5

STRATEGIES AND PROGRAMS FOR THE FUTURE 9

I. Elementary and Secondary School Levels 9

Teacher Preparation and Enhancement 9

A. Program Activities 9
  1. Teacher Enhancement 9
  2. Teacher Preparation 10
  3. Science and Mathematics Education Networks 10
  4. Presidential Awards for Excellence in Science and Mathematics Teaching 11

B. Impact in FY1993 12

Materials Development, Research, and Informal Science Education 12

A. Program Activities 12
  1. Instructional Materials Development 12
  2. Applications of Advanced Technologies 13
  3. Research in Teaching and Learning 13
  4. Informal Science Education 14
  5. Curriculum Utilization Program 15

B. Impact in FY1993 16

Studies and Program Assessment 16

A. Program Activities 16
  1. Studies and Analyses Program 16
  2. Program Assessment 17

B. Impact in FY1993 18

Young Scholars Program 18

II. Undergraduate Programs 19

A. Leadership Activities 19

B. Leveraged Program Activities.. 20
1. Instrumentation and Laboratory Improvement 21
2. Faculty Oriented Programs 21
3. Materials, Curricula, and Technologies 22
4. Institutional Development 22
5. Career Access Improvement 23
6. Research for Undergraduate Students 23
7. Planning and Evaluation 24

C. Impact in FY1993 24

III. Graduate Level and Beyond 26

A. Program Activities 26
1. Graduate/Predoctoral Programs 26
2. Postdoctoral/Young Faculty Programs 27
3. Pregraduate/Gateway Programs 28

Preface

This document comprises the National Science Foundation's "five-year strategic plan for science and engineering education," required (20 U.S.C. §3917) "to be up-dated on an annual basis, and submitted to the Committee on Labor and Human Resources of the Senate, and the Committee on Science and Technology of the House of Representatives by November 30 of each year."

The sections of this Plan pertaining to elementary and secondary education, and with education at the graduate level and beyond, deal exclusively with programs of the Directorate for Science and Engineering Education (SEE). The section on undergraduate education provides descriptive information for SEE's programs at that level and for those elements of the Foundation's educational activities that are distributed over the several research directorates but coordinated by SEE.

Public Law 98-371 required that the Foundation fund, from the FY1985 appropriation for SEE, "a contract to develop a science education plan and management structure for the Foundation." That mandate was carried out through the award of two contracts. Research Triangle Institute studied middle school science education programs; its report (RTI/3460-01FR) issued in December 1986. SRI International covered all precollege science and mathematics education, kindergarten through grade 12; its report (SRI Project No. 1809 under NSF Contract No. SPA-8651540) issued in two parts in May 1987 and April 1988. This Plan embodies major findings and recommendations of both these seminal studies.

The Office of Technology Assessment of the Congress published, in June 1988, an advisory report entitled "Educating Scientists and Engineers, Grade School to Grad School," (OTA-SET-377). Initial reactions to the findings and recommendations in that OTA report also are embodied in this Plan.

INTRODUCTION

A Strategic Plan is, by design, a plan for the long range. This document sets forth the goals and objectives of National Science Foundation education programming. But, ahead of those goals and objectives lies a vision of a state of science, engineering, mathematics, and technology education in the United States -- a state that, when achieved, will be self-adjusting to individual and National needs. The premise of this Plan is that education in science, engineering, mathematics, and technology must be available at every educational level in high quality and in forms that stimulate the interests of every student and citizen, and permit them to exercise intelligently their powers as citizens in an effective democracy.

1. ROLE OF THE NATIONAL SCIENCE FOUNDATION IN EDUCATION

In the National Science Foundation Act of 1950 (42 U.S.C. Sec. 1862, as amended) Congress authorizes and directs the Foundation "to initiate and support . . . science education programs at all levels in the mathematical, physical, medical, biological, social, and other sciences . . . and engineering education programs at all levels in the various fields of engineering."

The National Science Foundation has the background, stature, and capability to provide vigorous leadership and strong support to the Nation's efforts to strengthen its science, mathematics, and engineering education at every level.

Overall, the goals of NSF's education activities are to stimulate and lead nationwide efforts that will strengthen and accelerate the transmission, adaptation, and utilization of knowledge from the engineering, mathematical, and scientific disciplines; that will attract talented youth to careers in those fields and prepare them for sustained creative endeavor; and that will provide to students of every age and persuasion such background in the disciplines as will sustain their understanding and use of mathematics and science. Those goals encompass all levels of education and all stages of human resources development.

An Education Agenda for NSF

The National Science Foundation should:

- Expand programming that will improve the quality of education in mathematics, engineering, and the sciences for all students;
- Stimulate and support educational activities that will enhance the scientific, mathematical and technological literacy of the population; and

- Encourage and support the development of the Nation's scientific and technological human resources -- so that there is a full and steady stream of highly educated scientists, mathematicians, and engineers to participate in the Nation's research and production activities.

Strategic efforts should be aimed at:

- Expanding excellence in science, mathematics, and engineering instruction at all levels, and supporting the acceptance of higher expectations of student and institutional performance;
- Stimulating nationwide an increase in the amount of "hands-on" science available to students at every level, but especially in the elementary schools;
- Developing attractive and effective new courses and curricula that provide consistent and coherent mathematics and science alternatives for consideration by those who administer education programs;
- Increasing the effectiveness of teachers, faculty members, and supervisors --in part by extending the application, adoption, and use of new educational technologies;
- Developing means for decreasing the science and mathematics avoidance rates of female, minority, and disabled students, and increasing their interest in scientific and technical careers;
- Expanding the familiarity of both youth and adults with science, mathematics, and technology through formal and informal contact; and
- Increasing the number of research scientists who give attention and effort to the improvement of science, engineering, and mathematics education.

NSF's Composite Strategy for Change

The National Science Foundation at all times must have an education agenda and its leadership of educational improvement and reform must be proactive.

SRI International completed in 1987 a Congressionally-mandated study of alternatives available to the Foundation in the planning and management of its educational mission at the elementary and secondary levels. In the SRI report, "Opportunities for Strategic Investment in K-12 Science Education," NSF's present education programming was portrayed in terms of two contrasting strategies, with the note that the best strategy for the Foundation might be some combination of the two:

- An incremental improvement strategy -- which emphasizes stimulating and supporting a variety of incremental changes in educational systems (e.g. relatively short-term ventures to improve course materials, provide inservice retraining to teachers, and share the costs of new instructional instrumentation); and

- A fundamental change strategy -- which seeks to support changes that can improve education radically and in the long term (e.g. exploration of advanced technologies; research in the processes of teaching and learning; and reform of preservice teacher education).

This Strategic Plan is based on the conclusion that the National Science Foundation should employ a composite strategy in its education programming -- addressing simultaneously short-term objectives and long-term goals. A mixed strategy permits support of incremental changes that will benefit persons already in the formal education stream while fundamental changes are devised for the benefit of all students -- present and future. Incremental changes may also serve usefully as experimental steps toward the design of more widespread fundamental changes.

Another Aspect of NSF's Strategy

For too long, the Nation has deferred necessary maintenance of its educational systems; it has neglected the continuing efforts required to improve curricula; it has failed to install the best technology -- and then do it again; it has not been willing to assure the competence and confidence of the educators themselves; and it has in other ways failed to meet the ever-changing requirements of a varied and vigorous population. The results are to be seen in technical graduates fewer and less well educated than necessary; a citizenry poorly literate in science and technology; and economic competitiveness lagging that of the leader nations.

The National Science Foundation will continue to provide leadership in addressing this complex predicament in science, mathematics, engineering, and technology education. In working to "solve the problems" of education, NSF will seek out the very best people to be engaged; help them to make their best efforts; and assist the implementation of their findings. NSF will be flexible in the face of changing conditions, continuing the attack as the greatest need shifts from one area to another. The National Science Foundation's strategy in fulfilling its educational mission will be one of continuous investment -- and the Foundation will work with other Federal agencies and with the States to stimulate their programs of continuous investment to improve the quality and effectiveness of education nationwide.

2. THE DIRECTORATE FOR SCIENCE AND ENGINEERING EDUCATION

The Directorate for Science and Engineering Education (SEE) is the primary focus for education programming within the National Science Foundation, and is funded by Congress through a specific appropriation. Additional activities that impact education are conducted by each of the research directorates. SEE bears principal responsibility for implementation of the leadership and support roles played by the Foundation in science, mathematics, and engineering education, and is thus a principal trustee of the Foundation's education agenda.

SEE's Divisions of Teacher Preparation and Enhancement and of Materials Development, Research, and Informal Science Education are responsible for activities at the elementary and secondary school levels. The Division of Undergraduate Science, Engineering, and Mathematics Education coordinates the education activities found in the research directorates and manages undergraduate education programs of its own. SEE's Division of Research Career Development manages programs at the graduate and postdoctoral levels, as well as programs designed to reach science-interested students in middle and high schools. The Office of Studies and Program Assessment serves all units engaged in educational programming by supporting data collection, and analytic and evaluative studies of science, mathematics, technology, and engineering education at all levels.

The Directorate for Science and Engineering Education discharges many of the Foundation's education leadership and support responsibilities through programs dealing formally and informally with teachers, students, materials, and methods. Outside of SEE, each of the NSF research directorates supports a variety of activities that have direct impact on education.

NSF education programs have supported many projects designed to improve the quality and effectiveness of instruction in mathematics, engineering and the sciences. Capable educators have been helped to sharpen their professional skills, and individuals of high potential have been attracted to teaching in these fields. Materials development projects have provided exemplary tools and techniques that, after being adapted to local conditions, have been adopted widely in this country and abroad; and Foundation-sponsored research has led to deeper understanding of the processes of teaching and learning. In all of these areas, the involvement of the National Science Foundation has become a hallmark of excellence that encourages private sector and local public support

This Strategic Plan details the activities of the National Science Foundation that are sited in or coordinated and managed by the Directorate for Science and Engineering Education. At each level, efforts focus on points of strategic entry where NSF can help develop long-term national capabilities. The strategy is designed to mobilize the skills of scientists and educators at all levels, taking advantage of the Foundation's unique access to the science research and education communities. As appropriate, NSF coordinates its activities with the Department of Education and with other Federal agencies having education functions.

3. GOALS OF THE DIRECTORATE FOR SCIENCE AND ENGINEERING EDUCATION

The Directorate for Science and Engineering Education has four major long-range goals. Each of these goals gives rise to a number of objectives for the Directorate's education activities; and, in turn, each of the Directorate's programs addresses one or more of these goals through subsets of those objectives.

GOAL I: To help ensure that a high-quality school education in science is available to every child in the United States, sufficient to enable those who are interested and talented to pursue technical careers at all levels, especially in science and engineering, as well as to provide a base for understanding by all citizens.

The National Science Foundation plays a critical leadership role in elementary and secondary education. The problems are too diverse and their scope and complexity too great to expect that effective solutions will emerge spontaneously from uncoordinated local or state activities.

At the elementary and secondary school levels, NSF support will be targeted on:

- enhancing the subject-matter competence of present and future teachers;

- developing classroom materials that: reflect the state of scientific knowledge and its applications; are grounded in the best research on teaching and learning; will support the creation of several new, consistent, and coherent patterns of early science and mathematics education; and are well adapted to the differing needs of major segments of the student population;
- increasing the effectiveness and breadth of applications of advanced technologies to science and mathematics education;

- implementing new science and mathematics curricula in major school systems, and extending and networking the dissemination and exchange of information about successful curricula and instructional techniques; and

- conducting research on the processes of teaching and learning; developing indicators of student and teacher achievement, and better test instruments; and, acquiring reliable information on educational trends and progress nationwide and in other industrialized nations.

GOAL II: To help ensure that those who select scientific and engineering careers have available the best possible professional education in their discipline.

SEE will concentrate on the teachers, subject matter content, and classroom materials that are part of the teaching and learning processes at every level. Other NSF Directorates will continue to emphasize research as a tool for educating the next generation of scientists, mathematicians, and engineers.

The National Science Foundation's direct programming for the scientists, mathematicians, and engineers of tomorrow -- those in the disciplinary "pipelines" -- begins in the secondary schools, continues through the undergraduate and graduate years, and extends through advanced postdoctoral study to support of the pre-tenure research activities of young college and university faculty members.

The undergraduate and research career development activities of NSF during the period FY1989-FY1993 will be targeted on:

- providing modern equipment for undergraduate science and engineering instruction, especially as part of laboratory development efforts;
- supporting a variety of faculty-oriented programs to update disciplinary knowledge and sharpen instructional skills;
- stimulating continuous upgrading of science, mathematics and engineering curricula, especially projects that apply new instructional technologies, employ the results of learning research, and emphasize emerging or interdisciplinary fields and articulation with secondary schools;
- encouraging comprehensive intra-institutional and consortial efforts to improve undergraduate instruction;
- increasing the number of women, minorities, and the disabled who prepare for careers in science, mathematics, and engineering, and enhancing educational programs offered for them;
- expanding the opportunities for talented secondary school students and undergraduates to be involved directly in research and in other science-enriched environments;
- supporting programs of data collection, analysis, and dissemination to assist science, mathematics, and engineering education planning at all levels;
- providing direct support for the best graduate students in science, mathematics, and engineering; attracting top young investigators into academic faculty careers; and increasing opportunities for graduate and postdoctoral research abroad.

GOAL III: To help ensure that opportunities are available at the college level for interested nonspecialists to broaden their science backgrounds.

The great majority of students need a special kind of technical perspective and understanding to give them sophisticated insights into and acquaintance with the principles, practices, applications and limits of science.

Study of mathematics and the sciences is required in many curricula that prepare students for nontechnical, non-science careers. More often than not, students in these curricula take the same courses as do mathematics and science majors. An even greater fraction of college students -- those whose courses of study do not include mathematics, science, or technology -- have little opportunity to extend the knowledge they gained in school-based contact with these fields.

All college students should be able to take courses that provide sophisticated acquaintance with the principles, practices, and techniques of science, insights into its scope and limitations, and similar familiarity with mathematics and technology.

During the period covered by this Strategic Plan, the Foundation will initiate activities targeted on:

- developing new mathematics, science, and technology course offerings that will provide effective instruction to nonspecialists;
- supporting and disseminating such new instructional materials and model courses; and,
- encouraging and supporting the development of new instructional techniques to overcome the science and mathematics aversion of nonspecialist undergraduate students.

GOAL IV: To support informal science education programs to maintain public interest in, and awareness of, scientific and technological developments.

Much useful learning about science, mathematics, and technology is accomplished informally by both children and adults. Indeed, most adults will have only informal contact with these critical areas after they leave school or college. The Foundation is committed to efforts to assure a balanced and rich environment that encourages informal science learning across a broad range of interests, age, and sophistication. These efforts will utilize the broadcast media, museums, zoos, aquaria, science clubs and hobby groups. They will be designed to stimulate and maintain self-confident interest in science, mathematics, and technology in their large target population.

The informal science education activities of NSF during the period FY1989-FY1993 will be targeted on:

- developing, through radio, television, museums, and science clubs, a rich and motivating environment for informal science learning; and,

- bringing science museum and other community-based services to previously unserved audiences; and extending the reach and impact, and improving the quality and cost-effectiveness of all programming.

STRATEGIES AND PROGRAMS FOR THE FUTURE

The Directorate for Science and Engineering Education (SEE) is involved in the education activities of the National Science Foundation over the whole span of formal education (kindergarten through postdoctorate) and in many areas of informal education as well. Here, NSF's Strategic Plan for science and engineering education is described by educational level in terms that reflect SEE's internal organization.

I. ELEMENTARY AND SECONDARY SCHOOL LEVELS

SEE's Programs at the elementary and secondary school levels are concentrated in the Division of Teacher Preparation and Enhancement, the Division of Materials Development, Research, and Informal Science Education, and the Office of Studies and Program Assessment. One program at this level, the Young Scholars Program, is administered in the Division of Research Career Development.

TEACHER PREPARATION AND ENHANCEMENT

The Division of Teacher Preparation and Enhancement (DTPE) comprises the following Programs at the level of elementary and secondary schools: Teacher Enhancement (for active teachers), Teacher Preparation (for those studying for the profession), Science and Mathematics Education Networks (among active teachers), and Presidential Awards for Excellence in Science and Mathematics Teaching.

A. Program Activities

1. Teacher Enhancement

The Teacher Enhancement Program will provide support for model projects for inservice improvement of the qualifications and effectiveness of mathematics and science teachers.

In addition to expanding its program of general teacher enhancement activities, the Teacher Enhancement Program will:

- o Invite proposals for projects that focus the attention of teachers at the elementary and middle school levels on techniques for increasing classroom effectiveness through the use of advanced educational technology;
- o Seek proposals for programs, involving middle and secondary school teachers, that explore techniques for attracting minority, female, and disabled students to the study of science, mathematics, and technology;

- Stimulate relationships between scientists working in the private sector and school, college, and university projects that improve precollege science and mathematics education; and

- Emphasize projects that will develop sound ways to improve the capability of secondary school teachers to teach combinations of related subjects (e.g., chemistry and earth sciences, physics and mathematics, or chemistry and physics). Other projects will address other problems of small schools.

In order to assure the widest possible utilization of the products of the Nation's investment in teacher enhancement activities, the Program will support continuing evaluation of its completed teacher enhancement projects and mechanisms for disseminating information about them.

2. Teacher Preparation

The Teacher Preparation Program will provide support for innovative projects in the preservice education of future teachers of mathematics and science that address expert-identified short-falls in the content of teacher education and the intense problems in the profession that will arise because of current demographic trends.

In addition to maintaining its program of support for the development of innovative and effective curricula to prepare teachers to be truly expert in mathematics or individual science fields, the Teacher Preparation Program will:

- Invest in model programs for preparing secondary school physical science teachers to be competent in more than one discipline;

- Seek projects that will develop interdisciplinary and multidisciplinary college science offerings for the preparation of elementary school teachers;

- Support model projects designed to: (1) strengthen and sustain the interest that minority, female, and disabled students have in science, mathematics, and technology when in elementary and middle school, and attract these students to further study of these subjects in high school; (2) bring more rapidly into existing curricula the results of research on the processes of teaching and learning; and, (3) use advanced technologies to increase teacher effectiveness.

3. Science and Mathematics Education Networks

The Science and Mathematics Education Networks Program supports local or regional groups organized to share information, resources, and/or talent in service of a general or specific educational objective -- often, the improvement of some aspect of the delivery of educational service. The Foundation is especially interested in fostering use of the intellectual capital of business and industry and other private sector entities to address local and regional needs in K-12 education in partnership with school districts (and with other educational and professional entities, as appropriate).

In addition to funding meritorious unsolicited proposals received from the field, the Networks Program will:

- Invite projects designed for consensus building, coordination and collaboration, or the exchange of ideas related to future directions for the improvement of mathematics, science, and engineering education;
- Issue further solicitations, like those of FY1987 and FY1988, for support of Private Sector Partnerships (PSP);
- Support several projects designed to disseminate exemplary models, instructional materials, assessment information and research findings -- especially the output of successful projects supported by the Foundation; and
- Organize conferences to explore ways and means by which research scientists can be attracted to participate in school-focused activities to improve science and mathematics education.

4. Presidential Awards in Science and Mathematics Teaching

This program is designed to demonstrate the importance of good teaching by explicitly recognizing and rewarding each year the excellence achieved by some science and mathematics teachers. The Presidential Awards honor the teachers selected in gratifying and highly visible ways. Each awardee is provided with modest resources for future use, and the interactions of the Awards Week result in immediate and continuing sharing of ideas that extends well beyond each teacher's personal professional environment.

During the next five years:

- Efforts will be made to extend and strengthen the interactions of the Presidential Awardees with their colleague teachers;
- The scope of the Presidential Awards program will be broadened by including elementary, middle, and junior high school teachers. (Some of the latter are eligible at present.)

B. Impact in FY1993

By FY1993:

- Teacher Enhancement projects will reach directly several thousand leader teachers each year -- and each of them will assist the improvement of the qualifications of 5 to 50 additional teachers each year.
- Teacher Preparation projects (each involving one or more colleges and universities, and about half engaging a school district as well) will be accomplishing a variety of research and demonstration objectives in teacher preparation; some of the projects in each area will be supporting evaluation, dissemination, and implementation activities.
- Projects of the Networks Program will have broad and diverse impacts on the nationwide effort to raise and maintain the quality of science and mathematics education in its schools; its Private Sector Partnerships component will engage many industrial and business firms in such projects.
- There will have been almost 1200 Presidential Award winners. It is estimated that each one will have continuing direct influence on several other teachers and beneficial indirect influence on more.

MATERIALS DEVELOPMENT, RESEARCH, AND INFORMAL SCIENCE EDUCATION

The Division of Materials Development, Research, and Informal Science Education (MDRISE) comprises the following Programs: Instructional Materials Development, Applications of Advanced Technologies, Research in Teaching and Learning, and Informal Science Education.

A. Program Activities

1. Instructional Materials Development Program (IMD)

During the next five years, the highest priority of the Program will to be the development of model curricula in mathematics and science that promote the mathematics and science literacy of students at all grade levels, and build a sound background for disciplinary learning in both high school and college. Particular emphases will be placed on: impacting female, minority, and disabled students; introducing science early; preventing science/math aversion; using scientific and pedagogical research results; and catalyzing adoption of excellent new curriculum materials.

- Through a series of solicitations in science and in mathematics, the Foundation will invite proposals for comprehensive, integrated curriculum projects spanning the elementary, middle, and high school years; the focus will be shifted gradually from the elementary toward the secondary schools.

- A vigorous program of support for materials development will include generation of single- and multi-discipline course materials and teacher support materials for science and mathematics instruction at all grade levels.
- Projects will be sought to develop alternative, more comprehensive, and more demanding K-12 mathematics curricula, with instruction directed toward quantitative skills and insights that contribute to a problem-solving orientation.

The Foundation will continue to press for a combination of private publisher and public investment in major projects, and substantial academic participation to assure quality of content and pedagogy. NSF also will undertake widespread coordination with state and local planners and school systems to assure responsiveness to their needs and, later, a receptive environment.

2. Applications of Advanced Technologies (AAT)

The Applications of Advanced Technologies Program is responsible for supporting research, development, and demonstration in the use of state-of-the art computer and telecommunications technologies in science, mathematics, and engineering education. The Program seeks projects that will lay the research and conceptual foundation for technologies that will be available in five to ten years; highest priority is placed on developments promising order-of-magnitude increases in efficiency and breadth of application.

- The Program will continue its coordinated research efforts on intelligent tutors and knowledge-based systems, with special emphasis on proof-of-concept experiments with intelligent tutors in calculus, algebra, pre-algebra, and algorithmic problem solving. The combination of artificial intelligence, cognitive science, and advanced technology hold the promise of providing a quantum jump in student learning performance.
- The Program will support programming projects to develop powerful new computational tools and symbol manipulation systems for problem solving; these new tools and systems are expected to enhance the capacity of all students to cope with problems of steadily increasing complexity.

3. Research in Teaching and Learning

Expansion of basic knowledge about the processes of teaching and learning mathematics, technology, and the sciences, and about the factors that affect success in these fields, is the responsibility primarily of the Research in Teaching and Learning Program (RTL) in the Directorate for Science and Engineering Education.

Recent research suggests that the ways students learn are discipline-specific. Thus, both the teaching of topical material and of learning strategies must reflect the nature of the subject matter before the student. Research also suggests that the early development of cognitive competence follows a sequence of steps that is largely culture-independent.

During the next five years, the Program will:

- Support research on teaching and learning in specific knowledge domains (chemistry, physics, mathematics, biology, computer science, etc.) at both the school and college levels, placing strong emphasis on establishing the content and sequence of learning that can be most effective in developing science and mathematics literacy and problem-solving skills.
- Seek research projects on the effects and significance of the nature and quality of laboratory experiences at all levels.
- Invite proposals for projects to explore factors that may influence: student interest, participation, and achievement in science and mathematics; development of motivation and curiosity; and the making of curricular and career choices (and persistence in them) -- at various student ages and educational levels. There will be special emphasis on factors that influence underrepresented groups in their choices of courses of study.

To the extent that teaching is something beyond creating and maintaining an environment for student learning, a critical factor in determining what the student will learn is what the teacher knows and believes.

- Proposals will be invited for projects that will: (1) address the content and teaching of the curriculum for students as influenced by the preservice preparation of teachers; and, (2) carry out the conceptual/analytical work needed to define the content of professional competence examinations as they relate to science and mathematics teaching at the middle and high school levels, the corresponding development of the test instruments, and the research needed to validate them.

4. Informal Science Education Program (ISE)

The Informal Science Education Program utilizes broadcasting, museums, science clubs and other community-centered activities to assure a balanced and rich environment that encourages informal learning across a broad range. All aspects of the ISE program are designed to stimulate and maintain self-confident interest in science, mathematics, and technology.

- NSF/ISE's broadcasting projects will emphasize audience extension and will seek to improve the quality and variety of established television programs and series. ISE will support projects that: consolidate and extend the impact of core program series; maintain a continued but modest flow of new materials; explore the potential use and impact of new formats and media; develop alternative formats; and, encourage formation of linkages to museums and science clubs.

- ISE's support of science museums will encourage cooperation and the exchange of resources. The Program will invite proposals for projects that develop new strategies to: bring museum services to persons resident outside major population centers; extend audiences and services through cooperative development, multiple copies, and traveling exhibits; and, broaden the role of museums as centers for clubs, hobbies and community interest in science. ISE will endeavor to widen the participant spectrum by placing increasing emphasis on zoos, natural history museums, and aquaria, and by encouraging the involvement of newer and smaller museums in its programs.

- ISE's programming in the community activities area will increase support for clubs, groups, and organizations seeking to expand and improve the science content of recreational learning for young people. Special efforts will be made to: strengthen after-school activities targeted on the 6-14 years age group; support projects that focus on those who are underrepresented in science and technology (women, minorities, and disabled); experiment with family-centered science learning; provide advanced science enrichment for "high interest" children; and, explore new ways of identifying, supporting, and developing talent.

- The Informal Science Education Program will explore a variety of new and emerging alternatives to present delivery methods; for example: tradebooks and other home learning resources, home and library videotapes, and home or school-based adult education projects.

5. Curriculum Utilization

NSF is developing plans to establish a curriculum utilization program that will combine the outcomes of the Materials Development and Advanced Technologies programs in substantial two-year implementation projects sited in school systems of various sizes.

- Proposals would be invited first from large minority-dominant systems, each project comprising a sequence of activities such as curriculum examination and evaluation, curriculum improvement, and application of new materials to teacher enhancement. In the second or third year, proposals would be invited from small and medium-sized school systems.

B. Impact in FY1993

By FY1993:

- Materials Development and Applications of Advanced Technologies demonstration projects will involve hundreds of teachers and tens of thousands of students. The demonstration projects, if successful, will assure that tens of thousands of teachers and millions of students are reached by the varied products of these Foundation-sponsored activities.
- The results of Research in Teaching and Learning Program projects may affect the ways in which science and mathematics are taught to all students.
- Projects of the Informal Science Education Program reach millions of persons at modest cost.

STUDIES AND PROGRAM ASSESSMENT

Continuous efforts are required to guide educational program development in the Foundation. Within the Directorate for Science and Engineering Education, information acquisition and support of related policy studies are the responsibility of the Office of Studies and Program Assessment. The Office collaborates in these efforts with other NSF entities and with the U. S. Departments of Education and Labor, other Federal and state agencies, and colleges and universities as appropriate.

A. Program Activities

1. Studies and Analyses Program

The collection and analysis of data on science and engineering education issues, the support of related policy studies, and policy development is the domain of the Studies and Analyses Program.

NSF is currently sponsoring several research projects to develop "indicators" of the status of science and mathematics education. An indicator is a statistic that conveys a general impression of the nature of the system being examined, e.g., the percentage of high school graduates who have taken a year-long course in physics (20% in 1987), or the percentage of middle school mathematics teachers meeting certain (here those of the National Council of Teachers of Mathematics) recommended course-taking standards (only 10%). State, national, and international assessments of student achievements in mathematics, science and computer science are also being supported.

During the next five years, the Program will:

- Improve the validity of the indicators of student achievement, student learning behaviors (e.g., enrollment in science courses), teaching quality, curriculum quality, and financial and leadership support for science education, and assess the extent to which an indicator monitoring system can produce useful information for policy makers.
- Improve science and mathematics assessment procedures so that valid state, national and international studies will be implemented, and ensure that timely assessments will be conducted.
- Direct effort toward understanding the reasons for the relatively poor performance of U.S. students on international assessments, and support analyses of the results of the first state-by-state assessment in science and mathematics (to be implemented in 1990 by the National Center for Education Statistics).
- Support data gathering, trend analyses, and policy studies in several areas strongly related to nationwide education improvement efforts: supply and training of scientists, mathematicians, and engineers; teacher training, qualification, supply, and demand; content of instruction; state, urban, and rural educational reform movements; development of testing procedures to measure higher-order thinking skills; and undergraduate engineering, science, and mathematics education.

2. Program Assessment

Program assessment studies assist the Foundation to improve its own education activities, and provide descriptive and accountability information to schools, colleges and universities, and governments at all levels to help in planning efforts.

In the next five years, this component of the Program will:

- Place emphasis on identifying characteristics of high leverage programs and assessing the impact of specific NSF education activities or programs;
- Direct efforts toward the improvement of the process of program evaluation in science, mathematics, and engineering education;
- Assist states and local school districts to develop procedures for effective evaluation and implementation of innovative

textbooks and other instructional materials, student and teacher assessment procedures, and other school indicators;

- Invite proposals to establish one or two Centers for Evaluation and Dissemination of information derived from NSF-funded education programs; and,
- Conduct intergovernmental networks and conferences to assist in policy development and coordination, and to share information among states and other sectors.

B. Impact in FY1993

Projects supported by the Studies and Analyses Program and its Assessment Studies component are designed to acquire information and assist the development of policy to guide action. Their impact, though necessarily indirect, is potentially relevant to all technical education and its contributions to National well-being.

YOUNG SCHOLARS PROGRAM

The Young Scholars Program for talented secondary school students (initiated in FY1988 and administered by the Division of Research Career Development) focuses directly on students (especially members of underrepresented groups), stimulating their interest in mathematics, science, and engineering, and helping them maintain options. Over 3000 young men and women participate annually in Young Scholars projects.

During the next five years, the Young Scholars Program will be expanded moderately. The impact of the program should be seen in greater persistence by its participants in their preparation for careers in science and engineering.

II. UNDERGRADUATE PROGRAMS

NSF's undergraduate program is an agency-wide effort involving the Directorate for Science and Engineering Education (SEE) and the Foundation's research directorates. The Division of Undergraduate Science, Engineering, and Mathematics Education (USEME) within SEE serves as the focal point for undergraduate activities. USEME is responsible for:

- Managing undergraduate program activities budgeted within the SEE Directorate;
- Coordinating the NSF mission in undergraduate education across the Foundation; and
- Stimulating the involvement of academic scientists, their institutions, States, the private sector, and other Federal agencies in efforts to improve undergraduate education in mathematics, engineering, and the sciences.

Charged to administer some programs and to coordinate and manage others, USEME's task, broadly, is to bring the resources of all of the NSF Directorates effectively to bear on improving undergraduate education in all fields of concern to the Foundation.

Many kinds of institutions provide undergraduate education: two-year and community colleges, four-year colleges, and comprehensive and research universities. The NSF strategic plan for undergraduate education addresses the critical needs found in all kinds of colleges and universities, consistent with the recommendations of the National Science Board's Report -- "Undergraduate Science, Mathematics, and Engineering Education," (NSB 86-100). The plan comprises two major elements:

A. Leadership Activities to stimulate interest in and active support of undergraduate education by other sectors, i.e., scientists, academic institutions, the States, the private sector, and other Federal agencies; and

B. Leveraged Program Support to provide incentives for improvement, encourage high standards, generate models of excellence, and leverage local and State resources.

A. Leadership Activities

Among the leadership activities to be pursued during the next five years are these:

- Preparing short- and long-range program plans for NSF support of undergraduate science, mathematics, and engineering education -- in consultation with the other NSF Directorates, professional groups, the academic communities, and persons from the private sector;

- Expanding participation of undergraduate students and faculty in research;

- Developing programs that attract senior research faculty to activities will improve lower division undergraduate instruction;

- Encouraging cooperation and sharing of resources among colleges and universities to help control the costs of undergraduate instruction; and

- Supporting networks among the States and local higher education decision makers to disseminate information, share ideas, and develop cooperative strategies to improve the health of higher education in the sciences.

An important element in long-range program planning is exemplified by the series of workshops on undergraduate education conducted by USEME, in conjunction with NSF's research directorates. A 1986 triad dealt with issues in Mathematics, Engineering, and the Sciences, respectively, and yielded the first advice and counsel to NSF from these broad disciplinary communities in regard to the recommendations contained in the NSB Undergraduate Education Report (NSB 86-100). The participants were distinguished academic and industrial scientists, engineers, and administrators.

A second set of workshops was held between January and June, 1988, focused on specific disciplines -- Biology, Chemistry, Computer Science, Engineering, the Geosciences, Mathematics, and Physics. In addition a special workshop concentrating entirely on the Nation's two-year and community colleges was held in October 1988. The objectives of workshops in the second set were the same: to obtain a better understanding of the present condition of undergraduate education; to identify targets and predicaments of the highest priority; and to communicate to the Foundation the recommendations for NSF programmatic action from these national disciplinary communities. The plans for leveraged program activities that follow are based in significant measure on the advice and counsel from the 1986 and 1988 workshops.

B. Leveraged Program Activities

During the next five years, The National Science Foundation will expand or develop undergraduate programs in the following areas of critical concern: (1) Instrumentation and laboratory improvement; (2) Faculty-oriented programs; (3) Materials, curricula and technologies; (4) Institutional development; (5) Career access improvement; (6) Research for undergraduate students; and (7) Planning and evaluation.

1. Instrumentation and Laboratory Improvement

NSF's program for undergraduate instructional instrumentation and laboratory improvement is designed to discover and implement new approaches to improve the effectiveness and efficiency of laboratory instruction, especially through use of modern instrumentation.

- A substantial effort will be mounted to generate more effective and efficient approaches to laboratory instruction; the improvement of large-enrollment introductory laboratories is a special target. This effort comprises the College Science Instrumentation Program (CSIP) in SEE and Doctoral Universities Instrumentation (DUI) in the research directorates. This activity will strongly involve the research community, and will continue, as appropriate, the present requirement of CSIP for substantial cost sharing. Projects in two broad categories will be supported:

  Instrumentation: Model and standard setting projects to improve laboratory instruction through creative use of modern instrumentation and advanced technologies; and

  Laboratory Improvement: The conception, design, and testing of new approaches that are cost effective, powerfully stimulative of learning, and that reflect actual science and engineering practice.

2. Faculty-Oriented Programs

There is demonstrated need for opportunities and stimuli to assure that the nation's two- and four-year college and university teaching faculties remain vigorous and current in their disciplines. The Foundation's faculty-oriented activities at the undergraduate level will stimulate new ways (and share in the support of the best traditional ways) to improve the qualifications of college and university faculty through continuing education or research activities.

- NSF will mount new programs such as: a teacher-scholar program to recognize and stimulate outstanding undergraduate teaching; support for experienced faculty to pursue advanced studies, instructional development projects, or/and research; matching grants to accomplished scientists, mathematicians, and engineers to devote time to improving teaching (special emphasis will be given to introductory courses, and an industrial funds challenge will be included); and, a program to foster improved interaction between research scientists and college-level instructors by supporting workshops, seminars, educational projects, etc., for faculty at all levels.

3. Materials, Curricula, and Technologies

There is need for a variety of projects, large and small, to stimulate faculty efforts that will yield new undergraduate courses and curricula. In this area, the Foundation will emphasize: involvement of research-oriented faculty; timely applications of new knowledge and technologies; re-thinking professional and preprofessional curricula; courses for nonscientists; and the critical articulations -- high school with college, and two-year institutions with four-year.

During FY1990-FY1993, in partnership with the research directorates, SEE will develop activities such as:

- Support for several major, targeted curriculum development efforts (like those initiated in FY1988 on the undergraduate engineering curriculum and on the calculus);
- Study of the major beginning courses to generate new approaches, including courses offered to satisfy the curriculum requirements of nonscience majors;
- A program to provide incentives for scientists, mathematicians, and engineers to work creatively on course and materials development projects, create new software, and design new approaches to undergraduate instruction; and
- One or more centers for undergraduate instruction, each of sufficient size to provide a viable nucleus of talent to work on educational problems at that level. (Inquiries from the higher education community indicate interest in foci such as the individual scientific disciplines, various multidisciplinary combinations, and several emerging interdisciplinary areas.)

4. Institutional Development

The interactions within an institution of a number of high quality programs are synergistic; the same is true of consortial interactions among institutions. Hence, USEME Division plans to:

- Initiate a program of institutional challenge grants to colleges, universities, and consortia to support correlated and integrated sets of projects designed to improve undergraduate instructional programs (with emphases on cost-sharing, and on encouragement of partnerships with private sector organizations).
  A major subprogram will provide incentives for forming consortia each involving a lead university (or 4-year college) and a group of 2-year colleges to work on articulation between these types of institutions and to develop coordinated projects for improving lower division instruction in mathematics, the sciences, and pre-engineering technology.

5. Career Access Improvement

College-level programs to increase the numbers of minorities, women, and the disabled who are attracted to technical careers must follow successful precollege programs of the same type and intent if the strong drift toward nontechnical careers between high school and college is to be countered.

- NSF Comprehensive Regional Centers for Minorities will be supported in localities of high minority population; their programming will allow local institutions and agencies to work jointly, coherently, and systematically toward increasing the entry and success of minorities in the science, mathematics, and engineering pipelines.
- Model and demonstration projects (particularly at the interface with the high school and at the lower division level) will be supported that strengthen the capability of institutions to attract the underrepresented to study in NSF's fields.

These activities will complement NSF's Minority Research Centers of Excellence (MRCE) Program.

6. Research for Undergraduate Students

The Research Experiences for Undergraduates Program (REU) promotes direct collaborative participation in academic or industrial research by promising undergraduate students. The REU Program (1) supports the creation and operation of undergraduate research sites in established industrial and academic research laboratories, and (2) provides access to research experiences by incrementing current NSF research awards so that undergraduate students can be brought onto the research team.

- The expansion and evolution of the REU program will continue to emphasize involvement of students from underrepresented groups, and of those enrolled in colleges that do not have substantial established research programs; and
- A Complementary Program will be instituted that supports student research projects under the direction of a faculty member (complementing REU, which supports students to work on faculty research projects).
- Special programs will be mounted to expose undergraduates to the geosciences, and computer and information sciences; planning will be started on new approaches to introductory biological and behavioral science courses; and the Research Careers for Minority Scholars program will be expanded.

7. Planning and Evaluation

An important function of the Division of Undergraduate Science, Engineering, and Mathematics Education (USEME) will be to manage the collection and dissemination of information related to NSF's undergraduate mission. In the next five years, USEME will:

- Join with SEE's Office of Studies and Program Assessment, NSF's Science Resources Studies group, and the Department of Education to develop a data base activity related to undergraduate science, engineering, and mathematics education, in order to provide continuing information on faculty, students, faculty, instrumentation, expenditures, etc., for planners and decision makers; and
- Design and implement information dissemination mechanisms to assist continuing improvement of undergraduate science, mathematics, and engineering education.

C. Impact in FY1993

By FY1993:

- The Instrumentation and Laboratory Development program will be supporting projects in every state in every NSF discipline. Redevelopment of large enrollment laboratories will be well underway as will experimentation with computer control and simulation of various laboratory activities.
- Faculty members from colleges and universities across the nation will be attending refresher and enhancement sessions at regional sites, while additional faculty will participate in programs for individuals.
- Major changes in the Calculus and Engineering curricula will have been made at numerous colleges and universities. Many research-active faculty members will be involved in materials and curriculum development activities (especially in applying advanced technologies).
- The impacts of challenge grants will reach past the awardee college, university, or consortium, to influence similar and neighboring institutions through a ripple effect.
- NSF Comprehensive Regional Centers for Minorities will be located in several of the nation's major centers of minority population; their goal will be to achieve measurable success of their efforts to recruit and retain minority students in graduate degree programs in science and engineering. Career access improvement activities and outreach projects will have substantial impact on the institutions involved and on the

special communities they serve; there will be lively demand for exportation of these model projects.

- Research Experiences for Undergraduates and the Complementary Program will be reaching many college and university students interested in science, mathematics, and engineering. Both programs will have the same kind of substantial and favorable indirect impact as the Graduate Fellowship Programs.
- Planning and evaluation activities will result in improved development and management of the Foundation's undergraduate education programs.

III. GRADUATE LEVEL AND BEYOND

The Division of Research Career Development (RCD) is the administrative site of activities that relate to two widely separated stages in the development of the research careers of individuals. At the graduate and postdoctoral levels, the Division manages the Graduate and Minority Graduate Fellowships Programs, NATO Postdoctoral Fellowships in Science Program, Advanced Institute Travel Awards Program, and Presidential Young Investigator Awards Program; at the pregraduate level, it manages the Young Scholars Program.

A. Program Activities; and, Impacts in FY1993

The programs of the Division of Research Career Development are at the (1) Graduate/Predoctoral, (2) Postdoctoral/Young Faculty, and (3) Pregraduate/Gateway levels.

1. Graduate/Predoctoral Programs

SEE's principal research career development activities are the Graduate Fellowship Program and the Minority Graduate Fellowship Program. Through this prestigious pair of programs, a core group of outstanding graduate students is identified and provided extended support for advanced education.

FY 1989 is the first year of a three-year administrative transition to different timing of the obligation of funds for the whole Fellowship program. NSF is moving from obligation of funds in the fiscal year in which fellowship commitments are made (Old Payment Schedule) to obligation of funds in the fiscal year in which tenure is primarily exercised (Adjusted Schedule). The transition will encumber a one-time catchup increment of approximately $21 million in funding for the Fellowships Program in FY 1992. The planned transition is detailed in the following table.

	FY 1989	1990	1991	1992	1993
New Awards	860	1000	1100	1100	1100
Fellows on Tenure (Est.)	1950	2320	2630	2840	2950
Cost (Millions of dollars)					
Old Payment Schedule	$37.9	$47.2	$55.2	$59.7	$61.8
Adjusted Schedule	$24.0	$31.0	$36.0	$56.6	$61.8

This adjusted payment schedule will improve the management of funds across the Fellowship programs, more closely matching revenues to expenses.

During the next five years:

- A new Women in Engineering component of 80 Graduate Fellowships per year will be added to address the most serious deficiency in the generally broadening opportunities for women in science and engineering; this component will be funded jointly by the Directorate for Science and Engineering Education and the Directorate for Engineering;

- The number of new starts in the Graduate and Minority Graduate Fellowship Programs will be increased to 1020 per year, almost double the number in FY1987;
- A small number of Minority Graduate Fellowships will be awarded to undergraduate Juniors as an experiment in mitigating the high dropout rate from science and engineering career preparation by talented minority youth at the transition between undergraduate and graduate studies.
- Information on university tuition levels and the compensation paid to graduate research and teaching assistants will be used in the annual reviews of the levels of the Fellowship Program stipends and cost-of-education allowances.
- New opportunities will be identified to encourage short and long periods of study abroad by Graduate Fellows.

The Graduate Fellowship programs are effective instruments for encouraging the most highly talented young scientists, mathematicians, and engineers to undertake the rigors of graduate study.

2. Postdoctoral/Young Faculty Programs

The postdoctoral component of NSF's educational activities is the NATO Postdoctoral Fellowships in Science Program, through which outstanding recent doctoral recipients are enabled to study at overseas research sites. The program is administered by NSF but funded directly by NATO; it is likely to remain at its present size.

The Presidential Young Investigators Program is the young faculty component of NSF's education and research support activities. Through it outstanding young scientists, mathematicians, and engineers are helped to initiate and maintain the research activities that are expected of those in tenure-track faculty positions. Programmatic funds are provided by the various research directorates; total funding and the allocations of awards to the various disciplinary fields will continue to be reviewed and adjusted annually.

These two programs constitute the Foundation's efforts to make academic research careers attractive to the brightest young scientists, mathematicians, and engineers produced by the Nation's graduate schools, and to provide many of them with experience overseas to fit them for tomorrow's international research environment.

3. Pregraduate/Gateway Programs

[The Young Scholars Program for talented secondary school students is administered by the Division of Research Career Development. The description of the program is included in the earlier section on Elementary-Secondary education.]

The CHAIRMAN. Thank you very much.

The Chair recognizes the distinguished Dr. Robert W. Brown, Director of Educational Affairs Division, Office of External Affairs, NASA.

Dr. Brown.

Dr. BROWN. Thank you, Mr. Chairman. I am very pleased to be a witness before this distinguished Committee to discuss NASA's science, mathematics and technology education programs.

As the Committee and others have pointed out so clearly, the economic well being of our nation ultimately depends upon the scientific knowledge and the application of that knowledge which must come from a sustained talent pool of scientists and engineers and technicians, as well as a scientifically literate citizenry.

Mr. Chairman, we have prepared a detailed report for the Committee, and I'd like to hit some of the high points of our report.

NASA is a federal high tech R&D agency, and we are especially sensitive to the need for a highly trained work force. For without such a work force, we cannot achieve our three main goals of advancing scientific knowledge of the planet Earth, the solar system, and the universe beyond. We cannot expand our human presence beyond Earth into the solar system, and we cannot strengthen our aeronautics research and develop the technology to promote leadership in civil and military aviation without such a trained work force.

So that really, in the final analysis, our NASA product is new and fundamental knowledge, and education is the vehicle by which that knowledge is acquired and the vehicle by which we transfer that knowledge to others.

In addition to being a high tech R&D agency, NASA is also an education agency. And I'd like to explain what we mean by that term.

First, the Space Act itself directs us to expand human knowledge and directs us to arrange for the participation by the scientific community. And it also directs us to provide for the widest practicable and appropriate dissemination of information about the Agency's activities. Thus, our external educational activities at the elementary, the middle school and high school, as well as the universities, are carried out and administered in that context.

Second, the scientific and engineering and technological composition of NASA makes it an "education agency"—in quotes. About 54 percent of our over 2000 civil servants are scientists or engineers. As a result we have a work force, a civil service work force, that values the importance of education. And when education is mentioned, our employees step forward and say, "How can I help?"

The third reason as to why we define ourselves as an education agency is that our experience reveals that space is a magnet for learning. There is an intrinsic excitement that aeronautics and space seems to bring about in youngsters, those who are older and graybeards like myself, and really across the board.

We've observed, for example, that with students and young kids there are three things that you can predict will capture their attention. The first one is ghosts; the second are dinosaurs; and the third is space.

And we find as we mature the matter of dinosaurs and ghosts sort of recede into the background, but space remains something that is very much up front. And we try to take that motivational factor of space and integrate it into educational activities and use it. So we have an extensive educational program.

Our mandate in NASA neither has the broad scope and range as the Department of Education or the National Science Foundation. What we do emphasize is to use our unique aeronautics and space missions, our facilities, and our special constituencies to help produce a talent pool of skilled personnel for NASA itself, for the universities, for the aerospace industry, and for the nation at large.

My previous colleagues have mentioned some of the serious pipeline issues that preoccupy much of our attention. I will not dwell on those other than to simply list them because they are important. But we have observed too a decline in the number of students who are pursuing or preparing themselves for science and engineering or technical careers. We are concerned about the low math and science literacy of our citizens at the precollege level in contrast to citizens in other countries at comparable levels.

We are concerned about the declining proportion of 18 to 24 year olds which represent our college-going population.

We are greatly concerned about some of the studies which tell us by the year 2000 and beyond we will have an increase of perhaps 36 percent in the need for scientists and engineers.

We are concerned that much of the new work force will come from underrepresented minorities and women, groups who have traditionally not focused on the physical sciences and engineering.

And we are also concerned that at the Ph.D. level in particular that so many of the students are foreign nationals in contrast to American citizens.

This is exacerbated by the fact that many of the high school science and math teachers have never had a course in computer science or calculus. The National Science Teachers Association tells us that only about a third of the elementary teachers have had a college course in chemistry; only one-fifth a course in physics.

So against that backdrop of pipeline issues and mission of the Agency, we try to carry out a number of programs, as my colleague, Dr. Moore, has indicated, to capture students interests at the early age. We have research that tells us, unless you capture the attention of students in science and mathematics in some significant way by the third grade, the prospect of their developing an enduring interest in that diminishes over time. So, as a consequence, we are beefing up our elementary education programs.

We also try to channel more students into science and engineering career paths. And we do this with our middle school and high school programs. And then we try to attract and retain those students who have made those career choices, who are typically at the undergraduate and graduate level. And then we try to provide some support for the faculty at the universities and these institutions by a number of programs which we administer.

In summary with respect to our programs, we conducted a survey, and we at any one time administer over 160 aerospace education programs, reaching some approximately six million students, teachers and others. And the funding level for those programs is around $64 million a year.

Just to give you a flavor, Mr. Chairman, of some of those programs that we administer, one of which is the most common, most popular one, is our Spacemobile Program. We have about 26 specialists who drive a NASA van that has in it artifacts such as space shuttles and models of spacesuits, telemetry devices, satellites. And they go out to schools and conduct assemblies and classroom lectures. This is one of the most popular programs. Over 900,000 students were reached in the last year of that particular program, and our waiting list is two to three years before we can get to a particular school.

We have a very active program for our high school students and underrepresented minority students who work at our NASA field centers under a mentorship. We provide opportunities for students to develop experiments that theoretically could be tested in a wind tunnel or in zero gravity facilities. Our Mars colony illustration—and this was a precursor program that permitted students to develop experiments that could actually be flown on the shuttle. And so far we have flown some 19 student experiments on the shuttle, the last of which involved a bone healing experiment, and the other involving fertilized chicken embryos. And President Bush was kind enough to invite those students to the White House for a special honor.

With respect to some of our teacher programs, we have a number of teacher workshops that we provide for teachers who come into our field centers and work for a two-week period of time.

Our Teacher in Space Program is one which is very active. Barbara Morgan, who is our Teacher in Space designee, is under contract to our office. She carries out a number of activities throughout the country, as do many of the Teacher in Space ambassadors around the country.

We have a very active educational technology program where we do satellite broadcasting. Over the past year we've reached over 20,000 teachers around the country through this particular program.

At the undergraduate level we have an extensive co-op program at any given time. We have over 900 co-op students who represent about 40 percent of our new scientists and engineers who come to the Agency to work.

We have a very vigorous Advanced Design Program for engineering students in their last year who carry out space technology designs that may be ten, 15, 20 years into the future. We bring faculty into our NASA field centers for training.

We have a number of special small programs that address underrepresented minorities at historical black colleges and universities, for example.

Most recently we have administered for the first round the Space Grant College and Fellowship Program, which is intended to broaden the base of aeronautics and space at the university level, to involve partnerships with industries and partnerships between universities and also partnerships between graduate and undergraduate schools. And we have a very active public education program.

So that's just to give you a flavor, Mr. Chairman, of some of the variety of programs that we administer.

With respect to the coordination question, I might say that there are really three types of coordination that we carry out.

Number one, there are organizations like the National Science Teachers Association, the Council of Chief State School Officers, Oklahoma State University, who are direct contractors for us and carry out activities.

At another level, we work extensively with other space science organizations such as the Challenger Center for Space Science Education, the Young Astronaut Council, the Astronauts Memorial Foundation, and many others.

And then the third level of coordination deals with other federal agencies such as NSF, the Department of Education, the Department of Energy, and others.

Finally, Mr. Chairman, I'd like to just give you a list of where we see ourselves going in the future with respect to our aerospace education programs.

First, we want to modify but retain our five year educational affairs plan, which emphasizes elementary education, teacher education, underrepresented minorities, university improvement and educational technology. We want to retain it. We're in the second year of that five-year plan.

Secondly, we want to make more of our precollege programs have an R&D type flavor to test out new approaches, to discern the results, and disseminate that and make it available to others.

Thirdly, we plan to make the Space Grant College and Fellowship Act a model for university cooperation and curriculum expansion. We also plan to target colleges of education who are preparing teachers to become teachers so that they can be exposed to the motivational resources of aeronautics and space.

We plan to seek opportunities to co-fund with NSF and the Department of Education and others.

A very important area is that we would like to expand our Spacemobile Program. Currently we have 26 Spacemobiles. We would like to have a Spacemobile devoted to every state in the country to help with the backlog as well as to reach a larger number of students.

We also plan to establish a talent pool of aerospace education writers who an help us in developing educational material that we can make available to the community.

Then we plan to implement a new program that is called the National Scholars Program, particularly aimed at underrepresented minorities. That is an effort that will involve the cooperation of NSF, the Department of Education, private industry and others.

And, finally, we want to continue to demonstrate the alternative uses of educational technology to which I have cited.

So in summary, we are convinced that space represents a very powerful magnet for learning. The range of aerospace education programs and activities that we have established, elementary through post-graduate school, helps to expand student interest in science, mathematics and technology and, through our teacher education programs, helps to enrich other academic subjects as well.

In anticipation of Space Station Freedom and the projected series of planetary missions and other aerospace developments, our students will be exposed to a rich set of incentives to help prepare them for key roles in this nation's future work force. Our educational efforts in NASA will be further enriched by strengthening our coordination and partnerships with the agencies and organizations to which I just referred.

We are most appreciative of the leadership that this Committee is demonstrating by convening this important hearing on the Federal role in science and mathematics education.

And this concludes my remarks, Mr. Chairman. I would be pleased to respond to any questions from the Committee.

Thank you.

[The prepared statement of Dr. Brown follows:]

Hold for Release Until
Presented by Witness
May 24, 1989

Committee on Science, Space and Technology

House of Representatives

101st Congress

Statement by:
Dr. Robert W. Brown
Director, Educational Affairs
Office of External Relations

NASA
National Aeronautics and
Space Administration

Statement of

Dr. Robert W. Brown
Director, Educational Affairs Division
Office of External Relations

National Aeronautics and Space Administration

before the

Committee on Science, Space, and Technology

U.S. House of Representatives
May 24, 1989

INTRODUCTION

Mr. Chairman, I am pleased to be a witness before this distinguished committee to discuss NASA's science, mathematics, and technology education programs. As the committee and others have pointed out so clearly, the economic well-being of our Nation ultimately depends upon the scientific knowledge and applications that come from a sustained talent pool of scientists, engineers and technicians, as well as a scientifically literate citizenry.

There is a synergism between people and machines in this new technological age. When you come right down to it, however, people are the source of innovation, new knowledge, and technological breakthroughs. Human talents will determine whether the United States can maintain its competitive position in the world, and whether Americans will maintain their standards of living at home. Those talents are precious ingredients. They must be nurtured and supported, and should not be allowed to lie fallow.

As a Federal, high-technology research and development agency, NASA is especially sensitive to the need for a highly trained technical work force. Without such a work force, we cannot achieve our three major goals of advancing scientific knowledge of the planet Earth, the solar system, and the universe beyond; expanding human presence beyond the Earth into the solar system; and strengthening aeronautics research and developing technology to promote U.S. leadership in civil and military aviation. In the final analysis, NASA's product is new and fundamental human knowledge and the techniques, processes, and systems by which we acquire that knowledge. Education is the vehicle by which that human knowledge is acquired and transmitted. Therefore, in addition to our high-technology research and development charter, NASA is also an "Education Agency." Let me explain what we mean by that designation.

First, NASA's authorizing legislation, the Space Act, directs us to expand human knowledge, arrange for participation by the scientific community, and provide for the widest practicable and appropriate dissemination of information about the Agency's activities. Our external aerospace education and university programs are administered in that context.

Second, the science, engineering, and technological composition of NASA's work force, and the culture of the agency, results in individual employees placing a high premium on promoting quality educational activities. In FY 1988, some 54% of our 22,718 permanent civil service employees are scientists and engineers. In NASA, when it comes to education, our employees step forward and say "How can we help?"

Third, our experience has consistently revealed that space is a strong magnet for learning. The intrinsic excitement that space generates among students and adults alike, young and old, and across all racial, ethnic, and socioeconomic groups, represents a powerful motivational resource for all educational subjects, not just science, mathematics, and technology. It has been observed that three things seem to particularly capture young children's attention and imagination -- ghosts, dinosaurs, and space. As the young mature, ghosts and dinosaurs recede in significance but space remains.

Our educational mandate within NASA neither has nor seeks to have the broad range and scope of education as that of the Department of Education or the National Science Foundation. Rather, we emphasize and use our unique aeronautics and space missions, facilities, and special constituencies to help produce a talent pool of skilled personnel for NASA itself, the universities, the aerospace industry, and the Nation at large.

PIPELINE ISSUES

A series of critical science and engineering pipeline issues preoccupy much of our attention, as well as that of other organizations throughout the country. Among them are (1) the decline in the number of students who choose to prepare themselves for science and engineering careers; (2) the low science and mathematics literacy skills of our middle-school and high-school students when contrasted with comparable grade-level students in other industrialized countries; (3) the declining proportion of 18-24 year olds who represent the traditional college-going population; (4) the 36% projected increase in the number of scientists and engineers needed by the year 2000; (5) the expected large increase of under-represented minorities and women into the workforce in the early 21st century, a group that has not traditionally been drawn to the physical sciences and engineering professions; and (6) the declining proportion of U.S.

citizens pursuing PhD's in science and engineering, a figure in marked contrast to the increasing number of foreign nationals acquiring these advanced degrees from American universities.

These pipeline concerns are compounded by teacher preparation issues. For example, the 1983 Yearbook of the National Science Teachers Association reports that nearly one-half of all high-school science teachers have never had a course in computer science or calculus. And only one-third of elementary science teachers have had a college chemistry course and only one-fifth a physics course.

Given these kinds of pipeline issues, I would like to respond to the five following areas that the committee asked us to address:

1. NASA aerospace education programs designed to improve pre-college and undergraduate education in science, mathematics, and engineering, and current funding levels of these programs.
2. Our most successful aerospace education programs and how their success is evaluated.
3. The extent to which information about the most successful programs is disseminated to encourage replication by other government entities or private-sector organizations.
4. Efforts to coordinate NASA aerospace education programs and activities with related programs of other Federal agencies, states, and the private sector; and
5. Plans for future aerospace education programs.

NASA AEROSPACE EDUCATION PROGRAMS

The Educational Affairs Division, within the Office of External Relations, is the central organizational entity that NASA established to provide leadership and coordination for its external aerospace education programs, elementary through university levels. Counterpart educational units are located in each of NASA's nine field centers. The Educational Affairs Division's Five-Year Plan, covering FY 1988--FY 1992, provides the general framework for the NASA aerospace education program. It encompasses our changing priorities toward elementary education, teacher education, university programs, the new Space Grant College and Fellowship Program, under-represented minorities, educational technology, educational partnerships, and the long-standing and immensely popular Aerospace Education Services Program, commonly known as the Spacemobile Program.

An internal agencywide inventory completed in August of 1988, using FY 1987 data, revealed that NASA administers some 160 aerospace education programs and projects at the elementary, secondary, university, and post-graduate levels. The programs reached over 6 million participants annually at a cost of approximately $64 million. Of these programs, 59 were elementary and secondary, funded at $3.7 million; 37 were university focused at $41.2 million; 30 were minority outreach programs at $9.1 million; 17 were general public education programs at $200,000; and 19 were NASA employment education programs, which were not costed out. I have submitted for the record a copy of this inventory of NASA education programs and activities.

Relative to the pipeline issues cited earlier, some of our educational programs are designed primarily to capture a student's interest in science, mathematics, and technology at an early age and grade level. In the late 1950's, a similar concern existed in this country related to mathematics and science education. Most energies in education at that time were focused at the secondary level. We know from recent research that if students do not develop a significant interest in these areas by the third or fourth grade, the prospect of their developing an enduring interest diminishes with time.

Other NASA aerospace education programs seek to channel more students into science, engineering, and other related career paths, typically at the junior-high, senior-high, and undergraduate levels. Our university graduate and post-graduate programs focus on attracting and retaining students in critically needed aerospace disciplines, and on upgrading the knowledge, skills, and experiences of teachers and university faculty.

Pre-College Student Programs

Initiated in 1961, the Aerospace Education Services Program (AESP), commonly known as the "Spacemobile Program," consists of a corps of some 26 aerospace education specialists who drive NASA vans and visit elementary and secondary schools around the country, conducting school assemblies, classroom lectures, teacher inservice and preservice workshops, and community education enrichment programs. In disseminating scientific and technical information about NASA's activities and research, these specialists conduct aerospace-oriented learning activities by using models such as space shuttles, rockets, satellites, telemetry demonstrations, spacesuits, and space food, as well as by using interactive computers and laser disc players. They also provide curriculum consultation for teachers, make civic group presentations to promote science literacy, and grant interviews for television, radio, and newspaper groups. During FY 1988, the Spacemobile Program provided service to 876,000 students and 27,700 teachers through 4,200 assembly programs, visitations to 3,000 classrooms in 1,900 schools, and by conducting 1,600 teacher workshops. However, due to the extensive demand for the Spacemobile Program and the current funding which limits us to being able to provide only 26 specialists, the waiting list for school visits ranges from two to four years.

A small subset of the specialists also conducts a program of lectures at colleges, and carries out an Urban Community Enrichment Program (UCEP) by working collaboratively with up to 20 schools in an urban area for up to eight weeks (or a semester) at a time.

The Summer High School Apprenticeship Program (SHARP) provides an eight-week summer employment experience at NASA field centers for academically achieving under-represented minority students, each under the mentorship of a NASA scientist, engineer, or other technical specialist. Averaging 150 students per year, this has been one of NASA's most effective programs over the past eight years. Nearly all of the students graduate from high school, attend college and major in science, engineering, and other disciplines germane to NASA's interests. Many have graduated from college and are now either working professionally in their fields or attending graduate schools.

The Space Science Student Involvement Program (SSIP) is a partnership program administered through a contract with the National Science Teachers Association (NSTA). Students in grades 6 through 12 compete by developing aerospace related experiments that theoretically can be tested in a NASA zero-gravity facility, wind tunnel, or Space Station Freedom. Other aspects of the program include a Mars Settlement Illustration and a journalism competition about the SSIP program. During the 1987-88 program year, 1,945 students submitted entries, many of whom, through regional competition, defended their proposals before a team of NASA scientists and engineers. The competition resulted in 11 national winners at the senior-high level and three national winners at the junior-high level who received special awards of recognition, including eight scholarships, three computers, and ten expense-paid trips to a special NASA event. In this program, thousands of additional students who do not submit formal entries still are exposed to the program by creative teachers who incorporate the aerospace concepts and application materials into regular classroom activities.

SSIP's immediate predecessor, the Space Shuttle Student Involvement Program, has permitted 19 student experiments to fly on the Shuttle. The last two were on STS-29 this past February, involving an animal bone healing experiment and a study to determine the effects of space flight on the development of fertilized chicken embryos.

President Bush, as a measure of the importance that he accords education, honored the two students, their faculty advisers, and commercial underwriters by inviting them to the White House for special recognition, along with the STS-29 astronaut crew.

The NASA Orbiter-Naming Program was designed to enhance students' interest and enthusiasm for space exploration through educational projects related to space research, exploration, and discovery. Initially sponsored by Congressman Tom Lewis (R-Florida) in March of 1986, and subsequently authorized by Congress in October 1987, the legislation called for the name of NASA's new replacement orbiter to be selected from among suggestions submitted by students in elementary and secondary schools. Subsequently, NASA, in consultation with other Federal agencies and external educational associations, designed the program to ensure that it had a clear educational content. As a result, over 71,000 students representing 6,100 teams, each led by a school faculty member, entered the national competition. They prepared and submitted interdisciplinary classroom projects to support and justify the proposed orbiter name, which had to have been that of a sea vessel used in research or exploration. The name ultimately selected by the President was Endeavour, for both the winning elementary and secondary teams. The Endeavour was the ship used by James Cook in his exploration of the South Pacific and the Antarctic in the 18th century. The student teams, from Senatobia, Mississippi and Tallulah Falls, Georgia, along with their faculty team coordinators, were honored by the President in a White House ceremony on May 16, 1989, along with the STS-30 crew members who launched the Venus-bound Magellan Spacecraft from the Shuttle.

The Space Exposed Experiment Developed for Students (SEEDS) is a project designed to provide an opportunity for students in grade 5 through the university level to become involved in an aerospace education classroom activity to determine the effect of the space environment on tomato seeds that have been in orbit since April 1984. Some 12 million Rutgers tomato seeds are among the 57 experiments aboard the Long Duration Exposure Facility (LDEF). If plans succeed to retrieve LDEF with the Shuttle in December of this year or in January, 1990, the seeds will be distributed to over 116,000 teachers registered for this program, along with a set of control seeds that have not been in space. Students will participate in experiments comparing the two sets of seeds to determine germination and plant growth rates, the number and size of tomatoes produced, chlorophyll identification tests, and the effect of soil types on plant growth, as well as more advanced experiments involving chromosome mapping and enzyme and hormone tests. This unique program represents an educational partnership between NASA and the Park Seed Company of Greenwood, South Carolina.

Teacher Education Programs

NASA also supports a number of aerospace education programs that focus primarily on teachers. During the summer, the Spacemobile Program conducts teacher workshops that are usually coordinated through universities and school districts. During the FY 1988 school year, over 1,600 workshops were conducted involving 27,700 teachers.

Two more specialized aerospace education programs for teachers are the NASA Education Workshops for Mathematics, Science, and Pre-College Technology Teachers (NEWMAST) and the NASA Education Workshops for Elementary School Teachers (NEWEST). Designed for high school and elementary teachers respectively, these honors workshops provide a two-week structured experience for 215 teachers at NASA field centers, under the tutelage of NASA scientists, engineers, and education specialists. Drawing upon the science and technology resources of these facilities, the teachers develop related classroom curriculum materials to use when they return to their schools. Some of their lesson plans have enabled students to use information about the Apollo landing sites to learn to read polar coordinate systems and to identify locations by latitude and longitude. Other lesson plans help students correlate Landsat images with conventional road maps, thereby learning mapping skills and grid coordinate systems. The Space Station Freedom mock-up at Marshall Space Flight Center was used by some teachers to help their students design and construct a habitation module for a space station.

NASA's nine Teacher Resource Centers, located at each field center; the emerging series of NASA-supported Regional Teacher Resource Centers, usually located at universities; and one Central Operation of Resources for Educators Center (CORE), served over 60,000 teachers in FY 1988. These facilities provide a variety of NASA educational materials related to subject areas such as energy, physics, mathematics, space flight, aeronautics, technology utilization, physical science, social science, and art, as well as career-related information. In visiting these centers, teachers have access to materials in a variety of formats, including videotapes, slides, audiotapes, publications, lesson plans, and activity plans.

Another extremely important element of our teacher education programs is our very active Teacher in Space Program. Barbara Morgan, NASA'S Teacher in Space Designee, remains under contract to the Educational Affairs Division while teaching part-time at McCall-Donnelly Elementary School in McCall, Idaho. Since the *Challenger* accident, this intelligent, dedicated, and energetic teacher has made over 200 educational appearances to schools, universities, professional societies, civic organizations, and other groups. We hear from teachers around the country, indeed, around the world, who feel that their status as teachers has been enhanced in the eyes of their students and the community at large through their identification with the pioneering image of Christa McAuliffe and Barbara Morgan.

NASA remains committed to the long-term goal of providing space flight opportunities for persons outside the professional categories of NASA Astronaut and Payload Specialists when this contributes to approved NASA objectives or is determined to be in the national interest. However, NASA is devoting its attention to proving the Shuttle system capability for safe, reliable operations and to reducing the backlog of high-priority missions. Accordingly, flight opportunities are not available at this time. When NASA determines that a flight opportunity is available for a Space Flight Participant, first priority will be given to a "Teacher in Space" in fulfillment of space education plans.

In the meantime, Barbara Morgan and many of the 113 Teacher in Space Ambassadors are very actively conducting a variety of aerospace activities around the Nation, which is what the program is really about. For example, Barbara Morgan is involved in a nationwide effort with the National Congress of Parents and Teachers (National PTA) to promote mathematics education. Others are involved with classroom activities that promote space science and technology. Still others are involved with public television programs that use aerospace topics in their delivery.

NASA educational publications represent the primary resource for teachers seeking current, accurate information about aeronautics and space research and development. These publications compress the time lag between actual aeronautics and space activities and their being presented in the classroom. The textbook average of a five to seven-year delay is shortened in NASA educational publications to five to seven months. Teacher and student demand for NASA educational publications is intense. Many titles are quickly exhausted and require reprinting to keep pace with increasing demands. The most popular titles include A Meeting With the Universe, What's New on the Moon, Space Shuttle Wallsheet, Ten Years of Planetary Exploration Wallsheet, Spacemathematics, This Is NASA, Aerospace Careers, Space Station: The Next Logical Step, and many others.

Our active mailing lists include over 75,000 educators, who recently confirmed their wish to continue to receive NASA educational publications. In addition, most NASA educational publications are sold by the Superintendent of Documents, U.S. Government Printing Office, and some are produced and distributed at no cost to NASA by commercial publishers.

Educational technology is another approach that NASA uses to deliver aerospace educational services and information to the education community, and particularly to teachers. During the past two years, for example, we conducted eight satellite interactive videoconferences for elementary and secondary teachers around the nation who had receiving capability at their schools. These one-hour videoconferences covered such topics as the Hubble Space Telescope, Space Station Freedom, Aeronautics, Living in Space, Future Exploration, Launch Vehicle Preparation, and Technology for Your Classroom. Receiving sites ranged from a one-room elementary school in Alaska with a receiving dish, to a state satellite network in Missouri, to PBS stations in Los Angeles, California and Norfolk, Virginia. A typical live videoconference, which permits teachers to call in with questions, is downlinked to over 500 sites. For these series of broadcasts, we have reached an estimated 2,000 schools and 20,000 teachers who viewed each videoconference live or by videotape.

Another of our educational technology programs is the NASA Spacelink, an electronic information system for educators. A collection of NASA information and educational materials is stored on a computer at the Marshall Space Flight Center in Huntsville, Alabama. The system can be accessed over regular telephone lines. It is designed to communicate with a variety of computers and modems, especially those most commonly found in classrooms and homes. The only charge to the user of NASA Spacelink is the long distance calls. Established in February of 1988, 14,200 calls were made during the first year of operations, with each call averaging 8 minutes.

The compilation and publication of an Aerospace Education Software Bibliography is another NASA technology activity. The publication consists of an inventory of commercial and public domain computer software on aerospace education programs. The software is aimed at grade levels 3 through undergraduate school, with topics in astronomy, aeronautics, aerospace physics, manned space exploration, rocketry, and satellites.

Undergraduate Aerospace Education Programs and Projects

NASA administers a number of university-related programs aimed at undergraduate and graduate students, post-doctoral researchers, and university faculty. Since this testimony specifically addresses undergraduate opportunities, I will not describe in detail two of our larger programs: the NASA Graduate Student Researchers Program, with its Minority Graduate Program component and the NASA/NRC Resident Research Associateship Program. These programs, however, provide fellowship and research opportunities to approximately 600 graduate students and university faculty. All of our university programs are, however, exclusive of NASA's larger relationship to the university community through almost 6,000 research and development grants amounting to $366 million.

The agency's largest single undergraduate program is the Baccalaureate Cooperative Education Program, which is a NASA partnership with many of the Nation's colleges and universities. Cooperative education (Co-op) integrates college-level academic study with periods of meaningful, full-time work experience. This is achieved through a working agreement between each center and a number of universities. The agreement allows the students, through the interaction of both study and work experiences, to enhance their academic knowledge, personal development, and professional preparation. Approximately 940 undergraduates participated in the FY 1988 Co-op program.

A similarly large, but different undergraduate program is the NASA/USRA University Advanced Design Program, directed primarily at undergraduate senior engineering students. The purposes are to heighten university enthusiasm for design within the engineering curriculum; produce innovative advanced designs in aeronautics and space; and encourage U.S. students to seek graduate study and/or employment in aerospace fields. Currently, 36 universities and 8 NASA centers participate in this aerospace-related program. During the academic year, students enrolled in senior engineering design courses work on a design problem developed in conjunction with NASA centers. The study topics include potential space projects for the 21st century such as a lunar storage and transfer system and long-term space habitats. Students present their design projects to each other and to NASA officials at a summer conference. Following the conference, graduate teaching assistants spend a ten-week internship at a NASA center to plan the next semester's course.

Although not an undergraduate program, the NASA/American Society for Engineering Education Summer Faculty Fellowship Program has a direct impact on undergraduate students. Each summer, approximately 250 university faculty members spend 10 weeks at NASA centers conducting research on topics of mutual interest. Approximately 10% of that time is spent attending seminars on related topics. The program is designed to enhance the career development of university faculty, particularly those from smaller institutions without extensive research facilities. Participating faculty return to their institutions with new knowledge to incorporate into coursework and additional research opportunities for students. In 1987, a follow-up study was conducted on those who participated in the program between 1981-85. Summer faculty participants were able to support over 300 undergraduates in follow-up research grants and almost 52,000 students received the benefit of faculty members' experience through new courses and/or course material.

Many of NASA's undergraduate programs are small and specialized, with as few as 17 students in the NASA Ames Work Engagement Program for Scientific Technicians and 10 in the Jet Propulsion Laboratory's Planetary Geology Undergraduate Researcher Program. Other targeted programs include minority outreach programs designed to augment the Nation's engineering and science work force by helping to eliminate the under-representation of minorities, women, and the handicapped in these professions. The Xavier University Engineering Bridge Program, that currently prepares 46 Black students for an engineering curriculum is one example. A similar program that supports 17 Hispanic and 3 Native American students is the Recruitment and Retention for Excellence in Engineering Program at the University of New Mexico. In addition, over 200 undergraduate and graduate students through the Historically Black Colleges and Universities (HBCU) program are provided opportunities to work in a research environment at NASA centers. In addition to the obvious advantages to the students, the program increases the relationship and the involvement of HBCU's in NASA-sponsored research.

NASA's newest university program, which will eventually serve a significant number of undergraduate students, as well as graduate students, is the Space Grant College and Fellowship Program, mandated by Congress in 1987. The program's objectives are to (a) establish a national network of universities with interests and capabilities in aeronautics, space, and related fields; (b) encourage cooperative programs among universities, aerospace industry, and Federal, state, and local governments; (c) encourage interdisciplinary training, research, and public-service programs related to aerospace; (d) recruit and train professionals, especially women and under-represented minorities, for careers in aerospace science, technology, and allied fields; and (e) promote a strong science, mathematics, and technology education base from elementary through university levels. Up to 12 Space Grant Colleges/Consortia will be selected via a competitive, peer-reviewed process in August 1989.

Public Aerospace Education Programs.

Our Public Aerospace Education Programs have three particular characteristics that distinguish them from our other aerospace education programs. They reach exceedingly large public populations; they are more inclusive and go beyond the formalized education community of teachers and students; and the NASA information disseminated is offered in a more general rather than curricular format, or they are blends of all three. The best examples are Public Mail, Special Publications, and our Aerospace Community Involvement Programs.

Handling the large volume of public mail is a vigorous information dissemination activity for NASA. During FY 1988, over 290,000 letters were received, typically requesting information about NASA and related activities such as the operation of the Shuttle; the scientific basis for Unidentified Flying Objects; the effect of space exploration on Earth's weather; what it feels like to travel in space; and how to become an astronaut. Many requests ambitiously ask that we send "everything that you have about space." Approximately 85 percent of the public mail is from students and teachers.

NASA informational publications are especially popular with the general public. Remembered Images: 1958-1983, NASA Highlights 1986-1988, Aboard the Space Shuttle, How We Get Pictures From Space, Viking Pictures of Mars, Spinoff 1988, and many other titles have been sold by the Superintendent of Documents in record numbers. Another reason for the popularity of NASA informational publications is their high quality. Both text and illustration are produced to very high standards of excellence. Format and printing production are kept to similar high standards. In fact, every year NASA educational and informational publications receive the coveted Blue Pencil Awards from the National Association of Government Communicators for the most outstanding government publications of the year. The competition includes municipal and state governments, as well as the Federal government. NASA is proud of its leadership in educational and informational publications and is alert to the responsibilities of educating and informing its audiences as effectively as is possible, within the limits of its resources.

Each year, our Aerospace Community Involvement Program works with an average of three communities that range in size from two parishes in the Shreveport, Louisiana area to the entire State of Tennessee. Upon request, and when NASA resources permit, we assist a local planning group in informing the entire community about how aeronautics and space have an impact on their lives. NASA provides astronauts as speakers, sets up aerospace displays, sends a cadre of AESP specialists to lecture to schools and groups, and meets with local civic and business officials to stress the importance of better educating students who will become the work force of tomorrow. Typically, the elementary and secondary school system is the core of these one-to-three week programs, but they involve the infrastructure of the entire area as well.

EVALUATION AND SUCCESSFUL PROGRAMS

At the risk of appearing immodest, we consider essentially all of our aerospace education programs to be successful when measuring them against what the programs are designed to do. As indicated earlier in my testimony, the intent of our programs is to (a) capture students' interest in science, mathematics, and technology at an early age and grade level; (b) channel more students into science, engineering, and other related career paths at the middle-school and high-school levels; (c) attract and retain university students critically needed in aerospace disciplines; and (d) upgrade the knowledge, skills, and experiences of pre-college teachers and university faculty in areas of aeronautics and space. It is necessary for us to gather information related to our educational programs if we are to provide an effective service to the educational community.

The AESP contractor collects specific educational information for each school visited and teacher workshop conducted. A participant survey of videoconference users provided both technical and educational information, permitting us to improve our service to schools and teachers. Two university programs conduct surveys each year to improve programming. The Graduate Student Researchers Program surveys student participants related to their experience, and the Summer Faculty Fellowship Program surveys both participants and their NASA colleagues at each NASA center.

Other evaluation measures that we use are typically the volume of applications for the programs that we administer, and the various forms of feedback that we receive from both participants and observers. On both of these measures, our programs stand up very well.

DISSEMINATION AND REPLICATION OF PROGRAMS

The Aerospace Education Service Program (Spacemobile) would have to be considered one of our most successful programs. Now in its twenty-eighth year, the waiting list for school visits is still two to four years long. After each Spacemobile visit, teachers and others are asked to complete an 18-item evaluation document to assess the presenter's performance. The reports are uniformly positive, and we learn from their comments ways that we can improve our presentations. We also maintain a "rose letter" file for assessing feedback through letters from students, school officials, and others after a Spacemobile visit. We have made information about this program available to others for consideration of replication outside of NASA. However, the closest adaptation that we are aware of is the Science Connection, a mobile science education program that serves the southern California area. It is sponsored by the Southern California Edison Company, a public utility. The program was designed and is administered in collaboration with the education office at the Jet Propulsion Laboratory. Recently, we met with the staff of Sen. Don Nichols of Oklahoma to discuss the possibility of a privately supported "Spacemobile" for the State of Oklahoma. We would encourage other organizations to seriously consider the concept of a traveling education service similar to the Spacemobile program. But the product is as important as the process. The mission of the organization must have "market" appeal, and in that respect NASA is very fortunate.

The Advanced Design Program for undergraduate senior engineering students is another program whose success can be measured by its growth from a pilot effort of nine universities a few years ago, to presently 36 universities, with others wanting to become affiliated. Any further expansion, however, would require a larger NASA budget, and replication by other agencies is limited because they do not have aeronautics and space facilities.

The Summer High School Apprenticeship Program (SHARP) for minority high-school students has been remarkably successful in channeling students into college and then into science, engineering, and related disciplines as career choices. We are presently pursuing a splendid opportunity to encourage other organizations, both public and private, to replicate this program through our proposed National Scholars Program (NSP). The proposal is designed to produce 320 PhD under-represented minorities in science and engineering by the year 2000. Representing a collaboration between NASA, other Federal agencies, foundations, the private sector, and higher education institutions ranging from community colleges to universities, the program would cost approximately $3.5 million the first year, and $132 million by the 10th year of full operation.

The NASA Baccalaureate Cooperative Education Program has been a very successful program in producing a talent pool of young engineers who come to work for NASA after graduation. Although we have a tough time competing with industry because of their more competitive beginning salaries, the NASA facilities, environment, and mission are primary attractors in obtaining a fair number of these "freshouts" who represent about 40% of the new scientists and engineers that we hire each year. A number of other Federal and private organizations use similar co-op programs.

With respect to our Satellite Videoconferences for Educators, one of our objectives was to set an example of an educational technology delivery system. Even though we are now only in our second year, a notable number of education systems and organizations around the country are beginning to conduct such videoconferences with aeronautics and space technology as the principal subject matter. We believe that our efforts have been a contributing factor as measured in part by the number of requests we are getting for consultation in this area.

Finally, we can say with both a degree of satisfaction and frustration, all of our aerospace education programs are oversubscribed.

COORDINATION OF AEROSPACE EDUCATION ACTIVITIES

As a measure of how important coordination is to us, educational partnerships is one of the top priorities listed in our Five Year Plan. Pragmatically, we realize that NASA alone does not have sufficient resources to exclusively enhance the teaching of science, mathematics, and technology in the Nation's schools. We believe that if aeronautics and space concepts are to have some presence in this country's 83,000 elementary and secondary schools, with 45 million students, and 3 million teachers, as well as the 12 million students and faculty in higher education, we must form partnerships at the Federal agency, and other, levels. This is an area that creates one of our greatest challenges because coordination is not self-executing, and it is much easier to talk about it than to actually carry it out. Meaningful coordination is labor intensive and time consuming.

Three types of coordination best characterize our programs to date. The first covers organizations that operate aerospace programs for us through grants or contracts. Such arrangements include, for example, the National Science Teachers Association, Oklahoma State University, the

Universities Space Research Association, TRESP Associates, and the Council of Chief State School Officers. These are our strongest coordination efforts.

The second type of coordination covers other nonprofit education organizations. They include the Challenger Center for Space Science Education, the Young Astronaut Council, the Astronauts Memorial Foundation, the U.S. Space Foundation, the Alabama Space and Rocket Center (U.S. Space Camp), and the Science Service. Our relationships with these groups are relatively new, but are growing.

Other Federal agencies are the third target of coordination, and represent the area for which the most improvement is needed. One exception is the National Air and Space Museum with whom we have a very strong relationship. Other Federal agencies with whom we have worked but with whom much more progress must be made are the National Science Foundation, the U.S. Department of Education, the Department of Energy, the Department of Defense, and the Federal Aviation Agency.

Some corporate leaders are joining educators in partnerships to help with the Nation's education problems. NASA believes that their efforts are vital, especially in the areas of science, mathematics, and technology. We are, therefore, beginning to work with the aerospace industry to replicate proven models.

One such model is the Industry Initiatives for Math and Science Education (IISME). This five-year-old program is empowered by a consortium of San Francisco area educators and employers, including Ames Research Center. IISME gives science and math teachers a chance to step into the business world each summer and work for pay on discrete technical tasks. The over 270 teachers who have participated in the program, translate their research work into schoolwork, influencing some 40,000 students each year. In addition, their summer salaries of $600 per week boost their incomes and help to retain scarce science and math teachers in the profession.

By teaming with aerospace contractors, NASA has under review a plan to help replicate this industry initiative. A consortium would be established near each of the nine NASA field centers composed of the center and other area businesses. It would provide structured summer employment for teachers. We are discussing this effort as a partnership opportunity with the Triangle Coalition for Science and Technology Education. Costs would be funded by the National Science Foundation with some help from NASA.

In addition, we plan to encourage aerospace employees to consider second careers in science, mathematics, and technology teaching. This supports President Bush's program to encourage "alternative certification," which would "allow talented Americans from every field to teach in America's classrooms." As a result of recent orientation sessions at the Goddard Space Flight Center, for example, several Federal and contract engineers are now taking education courses in preparation for certification and a retirement career in science and mathematics teaching.

However, there are some disincentives to participate in this program. First, such employees may not be given administrative leave to attend their certification courses, nor to meet the requirements for observation and practice teaching time. Annual leave or other personal leave must be taken for these periods. Tuition is another problem since certification courses are not related to current duties and personnel, therefore, may not be compensated. A third inhibitor is the Federal tax law. It discourages those engineers and scientists who might volunteer to become science, mathematics, and technology teachers by "alternative certification." The tax law will not allow the deduction of tuition expenses because the required education courses are unrelated to current employment. The tax law also taxes stipends, should any of these employees decide to pursue graduate study and obtain fellowships after retirement.

It is clearly beyond NASA to recommend the resolution of these problems and there may be reasons that exist not to make changes. However, as long as these conditions continue to exist, our efforts and those of others to encourage more retiring scientists and engineers to prepare for second careers in teaching are much more difficult.

FUTURE PLANS FOR AEROSPACE EDUCATION

We have accumulated a set of experiences during the first two years of our Five Year Plan for aerospace education that signals the need to accomplish a more strategic impact, rather than a greater volume impact on the Nation's science, mathematics, and technology education system. The current constrained budget environment forces us to focus on those activities that make the broadest and most effective impact.

As Dr. Lennard A. Fisk, NASA's Associate Administrator for Space Science and Applications has testified, "We will launch 36 science missions in the next five years. And if we are smart, we will use these missions to conduct the biggest and most public science and engineering lesson ever, for the youth of this Nation. Each mission will reveal a different and wondrous aspect of science--whether it is in planetary exploration, or in material and life science research. And each is an engineering marvel. Let the youth of our Nation learn from what we are doing and be inspired to do better in their generation."

The following nine elements are the direction in which we would like to advance our aerospace education programs.

1. Modify, but retain, the priorities of our Five Year Plan, namely, elementary education, teacher education, university programs, the Space Grant College and Fellowship Program, under-represented minorities, educational technology, Spacemobile Program, and educational partnerships.

2. Design and structure some of our pre-college programs as demonstrations to test different approaches, assess outcomes, document results, and disseminate findings for adoption by others.

3. Use NASA's newly emerging Space Grant College and Fellowship Program as a model to promote partnerships and cooperation among universities, Federal, state and local governments, and aerospace industry, to encourage and facilitate the application of university resources to aerospace and related fields.

4. Seek opportunities for joint and coordinated funding and programs between NASA and the National Science Foundation, the Department of Education, and other Federal agencies.

5. Expand the Spacemobile Program by establishing a spacemobile for each state where justified by school population and distribution. Diversified approaches and experimental projects among the states will be used to assess the effectiveness of motivating more student and teacher interest in science, mathematics, and technology.

6. Target colleges of education to support a set of pilot projects to teach future teachers how to infuse aeronautics and space concepts into the existing curriculum of any school system in which they ultimately may be employed to teach.

7. Establish a wide talent pool of technical writers to produce, for NASA's dissemination, modular sets of supplementary curriculum materials featuring aeronautics and space. The materials will be drawn from NASA's aeronautics, space science, and technology missions and activities and tailored to specific school courses and subjects. The science and engineering expertise of the Astronauts Corps will be a key resource.

8. Implement the proposed National Scholars Program (NSP) which is designed to produce 320 PhDs from under-represented minorities in science and engineering by the year 2000.

9. Continue to demonstrate alternative uses of technology to deliver aerospace education services to teachers and students.

CLOSING SUMMARY

In summary, we are convinced that space represents a powerful magnet for learning. The range of aerospace education programs and activities that NASA has established, elementary through post-graduate school, helps to expand students' interests in science, mathematics, and technology, and through our teacher education programs, helps to enrich other academic subject areas as well.

In anticipation of Space Station Freedom, and the projected series of planetary missions and other aerospace developments, our students will be exposed to a rich set of incentives to help prepare them for key roles in this Nation's future work force. Our educational efforts in NASA will be further enriched by strengthening our coordination and partnerships with other Federal agencies and other organizations, both public and private.

We are most appreciative of the leadership that this committee is demonstrating by convening this important hearing on the Federal role in science and mathematics education. This concludes my prepared remarks. I would be pleased to respond to questions from the committee.

The CHAIRMAN. Thank you, Dr. Brown.

The Chair recognizes Mr. Frank Cipolla, Director of Management for the Department of Defense.

Mr. CIPOLLA. Thank you, Mr. Chairman. I am pleased to testify on behalf of the Department of Defense on our initiatives to strengthen science and engineering education.

I have a complete statement that I'd like to enter for the record.

The CHAIRMAN. With no objection, so ordered.

Mr. CIPOLLA. I will summarize here.

As you know, our national defense strategy has long been based on using superior technology to counter whatever advantages our adversaries have. But, obviously, superior technology can only be developed and maintained by scientifically and technologically skilled people.

Consequently, we in DOD have some special concerns. I'd like to put them in some kind of a context.

The Department of Defense directly employs over three million people, two million in uniform and one million civilians. Of the one million civilians who work in DOD, approximately 100,000—or ten percent of the civilian work force—are scientists and engineers. Of the two million uniformed personnel, almost three-quarters of a million enlisted men and women are technicians and require as a minimum a sound high school education in math and science.

Beyond our direct employment needs, DOD spending affects approximately 14 percent of scientists and engineers employed in the nation's industries. And, as you know, most of our contracts with private industry are for the development of the most sophisticated high technology projects.

I can only corroborate from our perspective the problems and trends that were discussed today. These trends become even more alarming for the scientific and technical community at large and with DOD, our specific scientific and technical needs, when viewed in the context of the expected changes in the composition of the work force.

While it is clear that DOD is going to have to rely more heavily in future years on women and minorities in its work force, it is discouraging to us that these groups are historically those most underrepresented in scientific and technical disciplines. And we're concerned about the fact that recent studies show that enrollments of these groups in S&E disciplines peaked in the early '80s and are now declining. We want to do what we can to help reverse that trend.

DOD is actively addressing the very questions raised by this Committee. Former Secretary of Defense Frank Carlucci established in September 1988 the Department of Defense Task Force on Human Resource Management in Science and Technology: Year 2000. He charged the Task Force to study, to report and to make recommendations on future DOD staffing needs in science and technology in light of the changing gender, ethic and racial composition of the labor force between now and the Year 2000.

The Task Force report, which, with your permission, I would like to submit for the record, was prepared in the form of a White Paper for the Secretary.

The **Chairman**. With no objection, we will make it part of the record at this point.

[The material referred to follows:]

DEPARTMENT OF DEFENSE
TASK FORCE ON HUMAN RESOURCE MANAGEMENT IN SCIENCE AND TECHNOLOGY: YEAR 2000

WHITE PAPER FOR THE SECRETARY OF DEFENSE

NOVEMBER 1988

TABLE OF CONTENTS

Foreword i

I Introduction 1

II Existing Interventions 3

III Changing Demographics 4

IV Human Resource Requirements 5

V Resource Strategy 7

VI Recommended Actions 10

Appendix

FOREWORD

Secretary Carlucci approved the recommendations contained in this White Paper on 13 December 1988. The White Paper is being distributed on a DoD wide basis, and actions have been initiated to implement the recommendations. The document contains, in addition to the conclusions and recommendations of the Task Force, a compendium of current initiatives under way in the Department that address this important issue.

I. INTRODUCTION

On 13 September, the Secretary of Defense established the Department of Defense Task Force on Human Resource Management in Science and Technology: Year 2000. He charged the Task Force to study, report and make recommendations on future DoD staffing needs in science and technology in light of the changing sex, ethnic, and racial composition of the labor force between now and the year 2000. The Secretary requested that the Task Force provide its first report in the form of a "White Paper" by 18 November. The report that follows outlines an agenda and program for the Secretary's approval and highlights some activities already under way within the Department.

All available data indicate that by the year 2000 the demographics of our work force will be remarkably different from what we have today. We will have fewer young people in the work force, more older people, fewer white males and more minorities and women. We will continue to have disabled persons in the work force who are being trained, educated and capable of moving into the work force mainstream.

It is more than evident that the requirement for science, engineering and technology occupations will increase in the next decade and beyond, probably at an even greater rate than we have experienced during the past decade, as our equipment and weaponry continue to grow more sophisticated and complex. It is just as evident that, because of demographic trends and educational gaps, the United States is facing a long-term shortage of scientists and engineers.

There are a number of programs in the Department of Defense which are helping to attract and retain all categories of individuals in the science and technology fields. We must, however, continue to look outward for recruitment sources, as well as inward at the quality of our internal working conditions, staffing flexibilities and options, advancement opportunities, training and development, compensation programs, dual career tracks and options, affirmative action goals and objectives. We must also continue to improve our image as an employer who strives for product excellence, superior personnel, innovative programs and quality working conditions.

DoD must rise to the challenge of anticipating and taking control of the national imperative to integrate women, minorities and disabled persons fully into our scientific and technological work force in a way that will fulfill our own needs to remain competitive. If we do, we will contribute significantly to assuring equal opportunity and full human resource utilization in the workplace. To do less would place us at great risk for the future. To do more will keep pace with those who will be competing with DoD for the same high quality candidates in the science and technology occupations in the future.

II. EXISTING INTERVENTIONS

DoD Components have a wide range of programs in place which are designed to increase the availability of scientific, engineering and technical skills in the DoD work force. The attached Appendix describes some of the significant interventions currently being used by Components. The nature of opportunities and target groups addressed by the programs vary widely ranging from pre-high school to college level students to science, engineering and technical professionals at various stages of their careers. Some of the intervention programs currently in place emphasize support of affirmative employment objectives by directing efforts primarily at minorities and females who are not equitably represented in DoD's scientific, engineering and technical work force. Some initiatives such as the Cooperative Education Program are used by most Components while others have been established by individual Components for their specific use.

The existing efforts and programs are commendable. It is clear, however, that additional efforts will have to be initiated if DoD is to deal effectively with the demographic shifts and constrained resource conditions that we expect to occur over the coming years. Specifically, expanded use of existing and new intervention programs will be essential to ensure the availability of skills to the extent required. Coordination of efforts, both within and across Component lines, will be necessary to ensure that the highest degree of cost effectiveness and program efficiency are achieved. Further, improved assessment of programs is essential to validate the quality of programs and ensure that efforts are achieving objectives.

III. CHANGING DEMOGRAPHICS

Demographic data indicate that by the year 2000, 85 percent of the new entrants to the national work force will be women, minorities, handicapped and immigrants. These changing demographics are caused by (1) the population and the labor force growing more slowly; (2) the average age of the population and the workforce rising; (3) more women entering the labor force; (4) minorities comprising a larger share of the new entrants into the work force; (5) immigrants representing the largest share of both population and labor force increases; and (6) education and skill requirements increasing.

These dramatic demographic phenomena will shape the American economy, social structure, and labor force and will have a direct impact on DoD's ability to meet its future needs in the science and engineering fields. Studies indicate that U.S. citizens are not being prepared adequately to meet the challenge. There is an alarming decline in the U.S. student enrollment and graduation from college in mathematics, science and engineering disciplines.

Declining enrollment of U.S. graduate students, due largely to their scoring in the lower end of the scale on mathematics achievement tests, is masked by the large number of foreign students in these fields. Foreign students comprised 75 percent of the graduate students receiving financial aid from university engineering departments and their high enrollment accounted for more than half of the Ph.D.s awarded in 1986. Their numbers influence selection for fellowships, research assistantships, and eligibility to become faculty members. Many first generation immigrants, however, will not be available for high technology positions in the Federal government due to language, educational, citizenship and security requirements.

DoD cannot avert the demographic facts and their impact on human resources. We will operate in an environment of increasingly more complex jobs with a declining labor market that will cause employers to provide higher entry-level wages and more flexible benefit packages. We will find ourselves in serious competition with other Federal agencies and private employers to meet DoD's science and engineering work force requirements.

IV. HUMAN RESOURCE REQUIREMENTS

Of the one million civilians DoD employs, approximately 10 percent are scientists and technologists (S&T). Of the two million members of the Uniformed Services, approximately three-quarters of one million are technicians requiring a sound background in high school mathematics and science, or higher. DoD spending affects 14 percent of the Nation's entire S&T workforce. Further, the U.S. Office of Technology Assessments (OTA) has postulated one model which estimates that for each $1 billion dollars (1983$) of DoD spending there could be an increase in demand for 1,000 additional S&T personnel if the money is spent on procurement and 4,000 additional S&T requirements if the money is spent on research and development.

Numerous studies by such organizations as the OTA, the National Academy of Sciences, and the Hudson Institute in its publications on *Workforce 2000* and *Civil Service 2000* have projected a decline in the number of young entrants into the work force and the number of people seeking S&T degrees. They have projected an increasing demand for S&T personnel, and foresee very disturbing trends for a decrease in the supply of these professionals—a shortfall of as much as 560,000 S&T personnel by the year 2000. This double decline in the number of entrants to the work force, and the participation in S&T degree programs, will affect both civilian and military recruitment as we compete with industry for a declining number of people at our traditional target of entry-level professionals, while at the same time our pay and benefits become increasingly noncompetitive. If left unchecked, the Department, because of a lack of an adequate supply of qualified and competent engineers and scientists, could suffer a degradation of its ability to respond to technological change, and its vital mission of National Defense.

Through the *Five Year Defense Program* years, and beyond, there will be a relatively flat manpower projection, with no significant increase in overall civilian staffing. However, it is anticipated that there will be a significant shift from the use of less technologically oriented administrative and support occupations to the science, technology and engineering professions. The study *Civil Service 2000* clearly shows this trend. The Defense Manpower Data Center reports that S&T employment has increased by more than 25,000 from December 1979 to June 1987, a 41 percent increase. If skills shifts continue as projected, we expect a 10 percent increase in the number of S&T personnel required by the year 2000. This trend will be further exacerbated by turnover of our S&T personnel. Even assuming a non-growth environment, and absent any major initiatives to improve retention, DoD can reasonably expect to have a loss of 7,000 to 10,000 S&T personnel a year due to turnover. Currently we are able to hire entry level replacements of engineers, but replacements of scientists have been declining over the last several years. These replacements will be difficult to recruit in the highly competitive and tighter labor market of the year 2000 in all S&T areas, but especially in the areas of biomedical and computer sciences. Due in part to its compensation and benefits programs the Federal government will become increasingly noncompetitive in an increasingly tighter labor market, at least through the year 2000.

The DoD can expect an increased demand for S&T professionals, caused by turnover, technological advancements, and skills shifts, and can expect that the increasing demand within the Department and in the general labor market, will outstrip the anticipated growth or supply of these skilled professionals by the year 2000. The Department will be facing a 25 to 30 percent increase in costs related to its investment in employee education and training caused by the pace of change and the learning needs of its employees. The gap that is projected between the supply and demand for S&T personnel, both within the Department and in the general labor market, will impact on the Department unless actions are started now, both within the Department and Federal structure, that will immediately improve near and mid-term prospects for recruitment and retention. Because of the number years it takes to produce S&T personnel, interventions must occur at all levels of the education system, including elementary and high school, to ensure an adequate supply. The National Academy of Science has found that such interventions must occur at all level of the education system, including elementary and high school, to ensure an adequate supply. The National Academy of Sciences has found that such interventions are effective in increasing interest and skills in S&T fields.

V. RESOURCE STRATEGY

Resources will be required to implement the recommendations of this White Paper. A precise definition of the requirements must await further analysis and staffing, but initial estimates, provided below, indicate that they will be relatively modest, in the context of the overall DoD budget. Contributions of resources should be shared by the Military Departments, and DoD Agencies such as the National Security Agency, Defense Intelligence Agency, Defense Mapping Agency, Defense Advanced Research Projects Agency, and Defense Communications Agency proportionately to the benefits they will receive as the result of implementation of the recommendations. By dividing the resource contributions in this way, an effective program can be structured and maintained over the long term without significant burden to any organization.

The following actions will require resources:

Immediate Staff Augmentation. To manage implementation of the analyses and other actions called for in the report, the Office of Assistant Secretary of Defense (Force Management and Personnel) will require a modest staff augementation. A total of four professionals and one secretary will be needed as soon as possible and will need to remain in place at least through FY 1990 to see the various reports and analyses discussed below through to completion. In addition, the Assistant Secretary of the Army (Manpower and Reserve Affairs) has agreed to task TRADOC to assist in defining the approach for assessing the military and civilian requirement for scientific, engineering and technical occupations and for defining strategies to meet the requirement. The Director, Administration and Management, has agreed to assist in providing an Executive Director, one secretary, office space and other support arrangements. Navy and Air Force should be requested to assist in providing the remaining personnel.

Requirements Analysis. Key to developing a successful program of interventions will be a much more precise definition of requirements for scientific and technical personnel. A contract should be awarded to develop such information beginning in FY 1989. We estimate that this effort will require $200,000 in FY 1989 and $300,00 in FY 1990.

Cost Model. To structure an expanded program of interventions in the most cost effective way, a model needs to be developed through which costs of alternative strategies may be estimated. Contract assistance will be required at a cost of $200,000 in 1989 and $300,000 in FY1990.

Defense Science Board (DBS) Study. The Task Force has agreed to look to the DSB to analyze the overall problem and recommend a long range program of actions. Among other areas, the DSB will be asked to examine whether a continuing advisory group or commission should be established. The purpose would be to provide for collaboration among involved government, academic and private organizations. This collaboration would bridge the communities of interest and cast DoD efforts in the context of broader, related national concerns. Conduct of the DSB Study would require the full-time assignment of a senior DoD individual (SES or equivalent) to serve as executive secretary for the DSB study team. The individual would require administrative support from OSD. This assignment should be made as soon as possible for FY 1989 and continue through FY 1990.

Should the DSB recommend a DoD or Presidential Commission, FY 1990 financing of up to $2M will be required. This figure is roughly the cost of the Packard Commission on DoD procurement, and is used as an uppper bound of financial requirements to implement such a DSB recommendation.

Interventions. Completion of the various analyses will result in the formulation of a program of interventions to increase the pool of qualified scientific and technical personnel through the remainder of this century and into the next one. Definitions of resources required for this program must await further analysis. However, we know that DoD will have to replace up to 10,000 such personnel annually just to remain even. The Department of Labor and such organizations as the Hudson Institute indicate that demand for technical skills in the federal work force will grow through the year 2000 by 10 to 30 percent in the various technical disciplines. Projections also indicate that, by the year 2000, only 15 percent of new entrants will be white males, the traditional source of technical skills. The remainder will be women, minorities, and immigrant groups that, for the most part, are underrepresented in the scientific and technical fields. It seems clear that aggressive interventions will be needed for the DoD to meet its needs over this period.

Costs for pre-college training are currently $1,000 per year per student, college co-op or scholarship programs cost $5,000 per year and graduate fellowships run $20,000 per year. Escalation of education costs have been expanding far beyond general inflation rates, and this trend is expected to continue. Interventions focused, for example, at 5,000 pre-college personnel, 2,000 college students and 1,000 graduate students would amount to $35M per year at current levels. This figure is meant to illustrate a general magnitude of costs and is not a definitive program or budget estimate. Substantial funding for the intervention program should be programmed in the FY 1992 Five Year Defense Program and budgeted beginning in FY 1991.

Resource Actions:

FY 1989 - Director, Administration and Management, should be requested to garner the resources needed in the short term.

FY 1990-1991 - The Comptroller is rapidly drawing the current 2-year budget review cycle to a close, with all Program Budget Decisions (PBDs) expected to be issued soon. Costs of interventions that may be recommended and approved by the Secretary of Defense at this point are undefined.

FY 1992 Program Period - The Defense Guidance (DG) sets forth policies and objectives that guide Components' development of the Program Objectives Memoranda (POMs). The process of developing the DG, which is an iterative one, will begin in February 1989 and, when completed, will guide the development of POMs for the 6 year period beginning in FY 1992. This period will be crucial. For interventions to succeed and produce a talented scientific and technical work force during the early part of the next century, investments must be made in the early to mid-1990s. To assure that this happens, language should be put into the forthcoming DG. The current DG contains the following policy guidance.

"*Civilian Work Force:* DoD civilian personnel and manpower systems must ensure a high quality, well trained, and productive civilian work force to support mission requrements."

Such policy guidance is totally relevant to the human resource management interventions. A mid-term objective should be added that provides specific guidance, e.g.:

> "In each program year, fund the interventions recommended by the Task Force, or Commission on Human Resources Management in Science and Technology and approved by the Secretary of Defense at a level sufficient to assure that accession and retention of scientific and technical personnel meet mision requirements through FY 2002."

VI. RECOMMENDED ACTIONS

Immediate

- DoD Components will implement a systematic plan to expand intervention programs to meet future needs in scientific, engineering and technological occupations. Consistent with demographic projections, intervention efforts should target minorities, women and disabled persons. Component plans should be completed by December 31, 1989, and provide for assessment of intervention programs to ensure accomplishment of objectives and cost-effective approaches.

- Actions should be taken to determine more precisely DoD's scientific and technical staffing requirements through the year 2000, and beyond. As a minimum, a contractor should be tasked to complete a definitive manpower requirements analysis and produce an analytical model capable of projecting specific resource requirements by skill. The Defense Manpower Data Center should assist in providing relevant data and analysis.

- The Defense Science Board should be tasked to review this issue and make recommendations for long-term DoD action. Among the matters to be reviewed should be the possible establishment of an appropriate level Commission or a long- term advisory committee for the Secretary of Defense.

- Immediate funding for administrative support should be approved as soon as possible. The short and long-range resource strategy outlined in Section V should be validated with as much definitive information as possible and submitted for Secretary of Defense approval by 30 March 1989.

- This issue should be included in the transition package for consideration as a priority item by the new Administration.

Short-Range

- DoD should identify initiatives to retain current employees in science, engineering and technological occupations. DoD must continue to seek legislative changes to the existing personnel system to improve its recruitment and retention of scientific and technological personnel. Such changes should include a new position classification and pay system, flexible benefits programs and improvements in the areas generally known as Quality of Life.

- DoD should identify initiatives directed toward providing professional credentials for current employees to enable them to enter scientific, engineering and technological occupations. Initiative should focus on:
    - the design of programs which provide current employees with educational opportunities leading to a degree in science, engineering and technology career fields. Upon graduation, reentry into the work force would be, as a minimum, at the employee's current grade level.
    - proposed legislation to change the current restrictions in the Government Employees' Training Act against agencies paying for an employee to obtain a degree.
- A project to develop a cost model should be established and funded. The model should include an estimation of training costs, which will reflect the cost implications and options resulting from skills shifts, occupational mobility, and interventions within the work force to ensure a highly competent pool of talent.
- DoD should explore opportunities within the DoD Dependents Schools System (DoDDS) and JROTC program for the enhancement of scientific/technical preparatory educational programs. DoDDS is prepared to establish such a program using "Magnet Schools in Science and Technology" (Appendix p.7).

Long-Range

- DoD should monitor and oversee its interventions and initiatives, identify new interventions and initiatives to be undertaken, analyze and evaluate work force needs for scientific and technological skills, and assess technological developments and forecast future requirements for personnel in scientific and technical disciplines. The next Administration should determine the appropriate structure for this purpose; i.e., continuation of a Task Force or the establishment of a special Commission or advisory committee for the Secretary of Defense.

APPENDIX

TABLE OF CONTENTS

PAGE NUMBER

PRE-COLLEGE PROGRAMS A-1

UNDERGRADUATE PROGRAMS A-8

GRADUATE LEVEL PROGRAMS A-12

FACULTY AND POSTDOCTORAL PROGRAMS A-16

RECRUITMENT PROGRAMS A-21

RETENTION PROGRAMS: DEVELOPMENTAL OPPORTUNITIES FOR DoD CIVILIANS A-25

PRE-COLLEGE PROGRAMS

Department of Defense Science and Engineering Apprenticeship Program

This is a DoD-wide program designed to have special appeal to minority and women high school students who are considered to have the potential to succeed in careers in the science and engineering professions. The broad objective of this program is to encourage and support careers in science and technology, identify talented students and provide them an opportunity to be stimulated by an 8-week working experience in a science or engineering environment. The program originated in 1979 in Washington, D.C., area Army and Navy laboratories. The program has expanded to include other Navy, Army, Air Force and DoD components, involving almost all of the DoD laboratories and nearly 1,000 students each summer.

Army Research and Office of Naval Research

Components of the Apprenticeship Program also place high school students with university-based researchers. Students selected work in university laboratories near their homes under the direction of university professors.

In addition, two associated programs have been established in the Washington, D.C. area involving a career exploration experience in science and engineering for junior high school students (STARS) and a teacher orientation program (TNT).

Science, Technology and Research Students (STARS)

This is a program for junior high school students. It provides a 3-day intensive program designed to encourage students to expand their horizons to include the possibility of technical careers, and guides them to high school course selections which include the necessary science and math courses for entry into science and technology studies in college. The majority of the program participants are minorities and females.

Teachers of New Technology (TNT)

This program provides, through a three credit graduate course, an update of trends in scientific research and strategies for improving the teaching of science. It also prepares science teachers to become "centers of influence" for upgrading educational standards, and for encouraging talented students to consider professional careers in science and technology. Teachers selected from the course group continue on to an 8-week laboratory research experience. Approximately 25 teachers participate each year, a third of whom are minority.

Adopt a School and Tutorial Programs

DoD Components participate in Adopt a School Programs. These programs and other tutorial initiatives permit wide latitude in approaches to assure that women, minorities and disabled persons are tutored, mentored, and provided encouragement and support to pursue studies in math, science and technology and to reach students at an early age to stimulate career interests in science and technology within the Department of Defense.

Federal Junior Fellowship Program

This program provides for career-related summer and vacation employment for outstanding high school seniors who need earnings to attend college. Students may serve in appointments during their 4 years of college attendance. Upon receipt of a bachelor's degree and completion of the requisite work periods, students are eligible for noncompetitive conversion to career-conditional appointments. Army currently has 243 participants. The Department of the Navy and the Defense Mapping Agency also use this program.

Summer Aid and Stay-in-School Programs

The objective of these programs is to employ financially needy students so that they can resume or continue their education. The program is limited to students who are at least 16 years of age and who are enrolled or accepted for enrollment as full-time students in a high school, vocational school or institution of higher learning. These are cyclical programs which allow students to work during summer and holiday periods, and up to 20 hours during the school term. Some activities have used these programs to stimulate interest in science and technology and to provide an opportunity to establish mentor relationships between employees and students. Army, Navy and the Defense Mapping Agency have used these programs extensively since their inception.

The Army Research Office Junior Science and Humanities Symposium (JSHS)

The JSHS program is intended to: 1) promote research and experimentation in the sciences, mathematics and engineering at the high school level; 2) search out talented youth and their teachers, recognize their accomplishments at symposia and encourage their continued interest and participation in the fields of science, mathematics and engineering; and 3) increase the number of future adults capable of conducting research and development. The Army Research Office, with some co-funding by participating academic institutions, is the principal source of funding for the symposium program.

Between September and April each year, 46 regional symposia are held at academic institutions around the country. Each symposium is a 2- or 3-day meeting attended by up to several hundred selected high school students and science teachers. Symposia typically include: 1) presentations of papers in which students describe research they have done while in high school; 2) presentations by scientists of current research of general interest and potential importance; 3) laboratory site-visits to observe professional researchers at work; 4) discussions of the societal aspects of scientific research and the associated responsibilities of researchers; and 5) discussions concerning research careers. Approximately 8,000 students participate annually.

Five students are selected from each regional symposium to attend the National JSHS, held on an alternating basis at the United States Military Academy in West Point, New York, or at another university. Seven students are selected annually to attend the London International Youth Science Fortnight.

Attendees at regional symposia generally receive reimbursement for room and board but receive no travel expenses. Those selected for the national and international symposia receive allowances for travel in addition to room and board. Students are nominated by their high school science teachers and selected by the participating academic institutions.

The Army Research Office/Office of Naval Research Uninitiated Introduction to Engineering (UNITE) Program

The purpose of the UNITE program is to provide special instruction in science and mathematics for socially and economically disadvantaged high school students. Universities annually hold 4-6 week sessions between June and mid-August. Total participation is approximately 215 students, most of whom are minority.

The Army and Navy share funding for the program with the participating universities. Laboratories near program locations also participate by introducing these future scientists to career opportunities in Service-related research and development.

Awards may include costs of travel and room and board. Applications are made available to students through guidance counselors or other advisors at their individual schools.

The Army Research Office Computer Related Engineering and Sciences Studies (CRESS) Program

The goal of the CRESS program is to provide an opportunity for highly motivated and gifted high school students to study computer science, both hardware and software. CRESS programs are held for 4 weeks during the summer at two university campuses: North Carolina State University in Raleigh, North Carolina, and the University of Miami in Coral Gables, Florida.

The CRESS programs are directed by electrical engineering faculties at the two universities. Participating students complete instructional and laboratory work in logic, microprocessing, robotics, and structured computer languages. They also are informed about Army interests in computers and computer-related fields.

The Army Research Office and two participating universities share funding for the program, which is managed under contract by the Academy of Applied Science. Awards generally include costs of room and board but do not include travel expenses.

Students are nominated by their high school science teachers and selected by the universities. The students must have completed Algebra I and II as prerequisities for CRESS participation. Approximately 50 students participate each summer, half of whom are minority.

Armed Forces Orientation to Engineering Careers (AFOTEC)

This program is a cooperative effort administered by the School of Engineering at Howard University and the College of Engineering at the University of Maryland. The 2-week orientation program provides high school level orientation on engineering. The program enables students to become acquainted with the type of effort required for college study; gain an insight and improved concept of various fields of engineering; observe the practice of engineering at Army laboratories; experience living in a dormitory; and gain experiences which would enhance chances to obtain further engineering training. Field trips are made to the Harry Diamond Laboratories and at least one other engineering-oriented facility.

Pre-Freshman Engineering Program (PREP)

The Defense Mapping Agency participates in the San Antonio PREP program as part of the President's Partners in Education Program, the DoD Partnerships in Education Initiatives and the Defense Mapping Agency's Affirmative Employment program. PREP provides an opportunity to expose pre-college level students to career opportunities in mapping, charting and geodesy (MC&G). For the past 4 years, this agency has provided lecturers, program staff support and instructors.

The purpose of PREP is to identify high ability middle school and high school students of the Greater San Antonio area who are potential engineers or scientists and to give them needed reinforcement to successfully pursue future college engineering and science studies. Women and minority students are special target groups. It is an academically intense 8-week program which stresses the development of abstract reasoning skills, problem solving skills and career opportunities in engineering and science. Participants must commit to 8 weeks of intellectually demanding classes and laboratories, with class assignments and lab projects. Examinations are given and participants are expected to maintain a 75 or better average during the program and the final grade is reported to the student's school.

Since 1979, over 2,000 students have completed at least one summer in PREP; 78 percent have come from minority groups underrepresented in science and engineering, and 48 percent have been women. PREP charges no tuition fees, thus, low income is not a barrier for application. PREP has been designated a Summer Youth Employment and Training Program (SYETP) worksite, allowing some poverty level participants to earn up to $800 by their PREP work experience. Financial and full-time inkind manpower staff support comes from local, state, and national colleges and universities; military commands; government agencies; private industry; and local school systems.

A follow-up survey was conducted in 1987 of all PREP participants. Responses were received from 555 of the 649 who were of college age; 416 attended college in the fall Of 1987; and 275 were enrolled in engineering and science courses. Out of a total of 73 graduates, 55 were engineering and science graduates. This is a successful public/private education intervention.

Grow Your Own "Programs"

Eligible high school seniors enter technical training programs which vary in duration but are all oriented toward developing skilled technicians in a variety of fields, including computer operations and engineering technology. Conducted by the National Security Agency, many of these programs are designed to train employees in nontechnical, intelligence-specific career fields. Participation varies widely from year to year, according to fluctuations in operational requirements.

High School Work Study Program

This program recruits high school juniors to work part-time during their senior year in a variety of disciplines. Although the majority enter nontechnical fields, such as clerical support, many perform computer operations. The National Security Agency employs approximately 150 students under this program.

Gifted and Talented Program

This is an experimental program, conducted in conjunction with a local school district. High potential high school seniors work in a scientific/technical specialty at the National Security Agency under the guidance of a mentor, who is a professional in that field. These students normally intend to pursue higher education in one of these fields, which distinguishes them somewhat from the majority of high school work study participants. This program is small in size, but worthy of expansion.

Career Launch
Magnet Schools in Science and Technology

Department of Defense Dependents Schools will identify and establish two secondary schools as technology magnets in overseas locations. Magnet school selection will focus on areas with high concentrations of children of Armed Forces members from minority groups. Enrollment will be open to all target students within commuting distance regardless of whether they live in the magnet school attendance area or not. The program will serve seventh and eighth grade students from the target group. The schools will work closely with parents to provide their child with continuing support and a fruitful environment for study at home. Successful high school juniors and seniors will serve as tutors and role models. Military representatives having technological assignments will be recruited to "adopt" students. Teachers in math and science and guidance counselors will be recruited specifically for their interest in serving these students and their parents. Students will learn to study in teams, develop mathematics problem-solving skills, acquire inquiry skills in science laboratory settings and become proficient in applying computer skills in various school disciplines. They will be connected through computers at home and at school, to information bases and electronic conferencing systems, which will develop their research and information retrieval skills. They will enter high school with a clear understanding of the opportunities in high technology fields and with skills that will support their work toward careers in those fields.

UNDERGRADUATE PROGRAMS

Cooperative (CO-OP) Education Program

This program has been used extensively by DoD components for many years. The emphasis of the program is to provide a positive work experience, coupled with a technical or professional education, that results in superior full-time candidates. Of the eight components queried, five use this program to attract science and technological entry level professionals. The Departments of the Army and Air Force, Defense Mapping Agency and the National Security Agency use the decentralized, locally funded and managed programs. Department of the Navy has a centrally funded and managed program, as well as decentralized, locally funded and managed programs.

The Department of the Army has active Co-op programs for graduate, baccalaureate and high school students. As of 31 August 1988, there are 21 graduate school participants, 702 baccalaureate level participants, and 163 high school participants.

The Department of the Navy has used the Cooperative Education Program for long-range planned intake of professional employees with math, science and engineering skills since 1976. The Navy uses a centralized Cooperative Education Program which is centrally funded and managed by the Chief of Naval Operations, and the decentralized concept which is funded and managed at the field activity level. The majority of the students in the centrally funded program are minorities and women.

Air Force uses Co-op programs to foster development of future Science and Technology employees at a number of Air Force Bases; e.g., the Aeronautical Systems Division at Wright-Patterson Air Force Base, Ohio, has approximately 100 students participating in their science and technology program.

The National Security Agency has tripled the use of the Co-op program over the past 10 years, and presently includes 260 positions, primarily in engineering, computer science and mathematics. The retention rate is nearly 80 percent, which far exceeds the industry average of 50 percent. The 1988/1989 recruitment schedule includes 8 historically black colleges and universities, 4 primarily Hispanic and Native American colleges, and 1 university for hearing-impaired students.

The Defense Mapping Agency uses the Co-op program to a limited extent.

Nurse Cooperative Education Program

A recently implemented adjunct of the Navy's centralized program is a special initiative to recruit Hispanic baccalaureate students in Nursing. The objective of this program is to alleviate the shortages in entry level nurse positions while simultaneously addressing the severe underrepresentation of Hispanics in the work force. The program was launched in January 1988 with recruiting trips to the Catholic University in Ponce, Puerto Rico, and the University of Puerto Rico in Mayaguez. There are currently 20 students participating in this program, and it is anticipated that at least 12 more will be selected on the next recruiting trip this fiscal year.

Department of the Army Scientific and Engineering (DASE) ROTC CO-OP Program

The goals of this program are to offer incentives to encourage scientific and engineering (S&E) students to join the Reserve Officers' Training Corps (ROTC) and to retain graduates first as military officers and second as civilian employees. It provides work experience as a supplement to educational experience, provides financial means for S&E students to remain in college and sells Defense components as "high tech" employers. Tuition assistance of up to $5,000 a year is available for participants who are not ROTC scholarship holders.

As of 31 August 1988, Army had 43 participants, of which 10 (23 percent) were minorities and 7 (16 percent) were women.

Undergraduate Training Program

This program was created in 1986 by Public Law 99-569. It provides full academic scholarships, salary at the Government Grade (GGD) 02 level and summer employment for high potential high school students who are pursuing bachelor's degrees in engineering, computer science, mathematics, and other NSA critical skills. This program is intended primarily, but not exclusively, for minority students. Upon graduation, the students are obligated to serve an equal number of years of fulltime employment at the agency.

The National Security Agency currently has 20 participants, of which 15 are minorities and 1 is handicapped. Five are women.

Air Force/University of Dayton Reentry Program

The reentry program is designed to recruit individuals (non-Federal employees) nationwide who have a baccalaureate or advanced degree in mathamatics/physics or the technical sciences to qualify as electrical engineers.

This is a 12-month program requiring completion of 39 semester hours of curriculum in electrical engineering with additional course work offered in software for electronic engineering conversion and electrical and magnetic field theory. A professional development component has also been added.

Students receive a Bachelor of Science degree in electrical engineering and incur a 3-year commitment to the Air Force Logistics Command (AFLC). Tuition is paid by the AFLC. Students are offered Federal employment when all second degree requirements are met.

Twenty-eight students are selected for classes beginning in April of each year. One hundred forty-one (141) students out of 144 graduated since 1982 have been hired at AFLC.

GRADUATE LEVEL PROGRAMS

FELLOWSHIPS AND SUMMER RESEARCH APPOINTMENTS

Army Research Initiative Fellows

Approximately 150 fellows are supported within the Army's 11 University Research Initiative Multidisciplinary research programs.

The Office of Naval Research Graduate Fellowship Program

The Office of Naval Research, through the American Society for Engineering Education, awards 3-year fellowships for study and research leading to a doctoral degree. Awards are made in science and engineering disciplines important to naval technology, and approximately 150 fellows are supported each year. Recent examples are: electrical engineering, applied physics, mathematics, naval architecture and ocean engineering, computer science, aerospace and mechanical engineering, cognitive and neural sciences, biological and biomedical sciences and materials sciences. Fellowships also are awarded for study in oceanography, with the special designation "Secretary of the Navy Fellowships in Oceanography."

These fellowships are tenable at doctorate-granting institutions in the United States. Fellows are encouraged to continue their studies during the summers in Navy laboratories.

The Air Force Laboratory Graduate Fellowship Program

This program, one component of the Air Force University Research Initiative, supports U.S. citizens for doctoral studies in areas designated by Air Force laboratories. Recent examples are: electrical engineering; mechanical engineering; aeronautical and astronautical engineering; biomedical engineering; chemical, industrial and civil engineering; physics; computer modeling; computer science; toxicology; chemistry; mathematics; metallurgy; meteorology and geophysics; life sciences, biology, biophysics; and behavioral sciences. The program is managed under contract by Universal Energy Systems. Fellowships are for 3 years. Approximately 50 fellows will be receiving support in FY89.

The Air Force Graduate Student Research Program

This program is intended as an adjunct to the Summer Faculty Research Program. It provides research funds for graduate students to work at an Air Force facility with a supervising professor who holds a current Summer Faculty Research appointment, or is a Resident Research Investigator. Provisions have been made for applications from graduate students who do not have a Summer Faculty Program supervising professor. Of the 113 students who participated in FY88, 14 were from Historically Black Colleges and Universities.

The Air Force Thermionic Research Initiative (ATRI)

The ATRI program is focused on multidisciplinary research and education in microwave and millimeter wave tubes. It is centered at the University of California, Los Angeles, and supported by the Air Force Office of Scientific Research with co-sponsorship of the major U.S. tube companies. Fellowships are available to U.S. citizens for graduate study and research leading to Masters or Ph.D. degrees.

The Air Force Research in Aircraft Propulsion Technology (AFRAPT) Program

This program was initiated in 1982 to attract students for research in aircraft propulsion technology. It is conducted concurrently at five universities with programs that lead to a Ph.D. degree: Massachusetts Institute of Technology and Purdue University in fluid mechanics and structures; Texas A&M University in structures; and Princeton University and Pennsylvania State University in combustion.

The program is a cooperative arrangement with AVCO Lycoming, Detroit Diesel Allison, Garrett, General Electric, and Pratt and Whitney Aircraft. To be accepted into the program, graduating seniors must be accepted for part-time employment by one of the companies and, for graduate study, by one of the universities. Each participant is a full-time, paid, research trainee of a participating university.

The Air Force Manufacturing Sciences Program

This program is run through the Air Force Wright Aeronautical Laboratories and the Air Force Office of Scientific Research. In the past, the program has had two university-based centers, one at Stanford University and one at the University of Michigan, although this program is currently being redesigned. Advisory boards for the centers represent industry, the universities and the Air Force.

The students perform research at the university-based centers or at the sponsoring company. The Air Force provides the assistantship funds for the masters and doctoral programs.

NSA Summer Program

This program is reserved for graduate level and exceptional undergraduate engineers, computer scientists and mathematicians interested in summer employment. The expectation is that when exposed to the "state of the art" work performed at the agency, the students will seek full-time employment upon graduation.

The National Security Agency employed 65 applicants in 1987, and approximately 66 percent chose to return to full-time employment upon graduation.

Research Services of Students

Section 603, Title VI of the Defense Authorization Act of 1982, P.L. 97-86 amended Chapter 139 of Title 10 of the United States Code of authorize the Secretary of Defense to "Procure by contract . . . the temporary or intermittent services of students at institutions of higher learning for the purpose of providing technical support at defense research and development laboratories." Regulations implementing this statute were made a part of the DoD acquisition regulations in 1983. The Army appears to make the most use of this authority: the Army Medical Research and Development Command employs about 400 students and the Army Corps of Engineers, about 350 students, in their research laboratories each year. Participants are principally graduate students.

FACULTY AND POSTDOCTORAL PROGRAMS

Historically Black Colleges and Universities (HBCUs)/ Minority Institutions (MIs)

This program provides scientific and technological talent for DoD components. Funds are allocated to support fellowships, traineeships, recruitment, student tuition assistance, scholarships and research projects in various disciplines, including science and technology.

This program also sponsors a Summer Faculty Exchange Program in which HBCUs/MIs faculty members are placed in staff positions at DoD activities. This exchange program is designed to familiarize faculty members with DoD components and to explore or identify areas where curricula could be developed to prepare students for entry level employment within the Department of Defense. This exchange program has been very successful.

The U.S. Army Summer Faculty Research and Engineering Program

This program is sponsored by the Department of the Army, the U.S. Army Research Office, and participating Army laboratories, and is managed under contract by Battelle Memorial Institute. Under the program, science and engineering faculty from universities spend 10 continuous weeks at Army laboratories between May and September. Approximately 85 faculty members participated in FY88.

Research sites are arranged by personal consultation with laboratory personnel. Two choices may be indicated by the faculty member when applying.

In addition to the summer salary, travel and per diem expenses are allowed for relocation. Follow-on support, not to exceed $25,000, is available at the applicant's home institution through the Post Laboratory Research Cooperative Program/Post Summer Faculty Research and Engineering Program.

Department of the Army Resident Research Associateships

These postdoctoral fellowships, awarded through the National Research Council, are open to U.S. citizens on a competitive basis. A postdoctoral or senior scientist with research expertise that is applicable to Army technical interests is supported for research in an Army facility for 1 year, with possibility for renewal.

Bunting Institute/Radcliff College
Women in Science Program

The Office of Naval Research (ONR) sponsors a program designed to encourage the research and teaching careers of women in science by providing post doctoral opportunities in an academic research setting. The Mary Bunting Institute provides 1- to 2-year sabbatical-like opportunities for women in various fields, including the sciences. This program supports the science scholars program which focuses on postdoctoral opportunities for women in science. The Office of Naval Research began its support for this program in 1980 with four scholars, and has increased its support to six scholars during FY89 at a cost of $20,000 annually for each scholar's stipend, plus a $2,000 allowance for research expenses.

The Office of Naval Research Young Investigator Program

This program supports young science and engineering faculty who show exceptional promise for doing creative research. The objectives of the program, which is one component of the Navy University Research Initiative program, are to: 1) attract outstanding young university faculty members to naval research; 2) support their research; and 3) encourage their teaching and research careers. Each year, ONR makes approximately 12 awards to U.S. academic researchers who have held a Ph.D. or equivalent degree for less than 5 years.

Each successful applicant receives a basic award of $50,000 a year for 3 years. In addition, an initial award for equipment may be made the first year based upon needs of the proposed research. As an incentive for becoming involved with other research activities, ONR matches on a 2-for-1 basis any support which the successful applicant obtains from naval sources outside the Office of Naval Research. These sources include Navy laboratories and system commands.

The U.S. Navy-ASEE Summer Faculty Research Program

This program is conducted by the Office of Naval Research and managed under contract by the American Society of Engineering Education (ASEE). Under the program, approximately 160 science and engineering faculty nominally spend 10 weeks at Navy research and development centers between June and August.

Research sites may be arranged personally by the faculty member through consultation with Navy laboratory personnel or through the ASEE. In addition to the summer salary, modest allowances are also provided for pre-program travel and relocation expenses. There is no formal program for follow-on support. Application deadlines are in January.

The Office of Naval Research
Postdoctoral Cooperative Research Associateships

The Office of Naval Research also awards postdoctoral fellowships to U.S. citizens through the National Research Council. This program offers opportunities to conduct basic and applied research at the Naval Research Laboratory in Washington, D.C., and the Naval Ocean Research and Development Activity in Bay St. Louis, Mississippi. Appointments are for 2 years.

The Office of Naval Technolgy
Postdoctoral Fellowship Program

These fellowships are designed to increase the participation of scientists and engineers in disciplines relevant to naval technology. The American Society for Engineering Education administers the postdoctoral appointments for the Office of Naval Technology.

Applicants may choose to work at Navy centers and laboratories, in areas of mutual interest to the Navy and the applicant, and use unique Navy laboratory equipment and facilities. Candidates are considered for appointment four times per year. Appointments are for 1 year, renewable for a second year.

U.S. Air Force Summer Faculty Research Program.

This program is sponsored by the Air Force Office of Scientific Research and is managed under contract by Universal Energy Systems. Science and engineering faculty spend 10 continuous weeks between April and September at an Air Force research activity. In FY 88, 157 faculty participated, 18 of whom were Historically Black Colleges and Universities faculty members.

Research may be arranged by the faculty member through consultation with laboratory personnel. Alternatively, the faculty member's application may be distributed to a number of laboratories where a conjunction of interest might be expected. There are allowances for travel in addition to the summer salary. The Research Initiation Program provides up to $20,000 in follow-on support at the faculty member's home. Twenty-three participants won Research Initiation Awards; seven winners were Historically Black Colleges and Universities faculty members.

EXCHANGES AND SUMMER FACULTY POSITIONS IN DOD LABORATORIES

University Resident Research Program (URRP)

The URRP provides university faculty members with 1-year appointments at Air Force laboratories or at the Air Force Office of Scientific Research (AFOSR). AFOSR funds the program and furnishes the necessary support services, facilities and equipment for the research. Twenty-three faculty members participated in this program in FY 88.

To be eligible for participation, an individual must: 1) be a U.S. citizen currently serving as a full-time faculty member of a U.S. institution of higher education; 2) have earned a Ph.D. in science or engineering; and 3) have a publication record in the proposed area of research. Letters of endorsement from the university dean and department chairperson are required for each appointment.

The period of assignment is 1 year, unless the needs of the Air Force require an extension. The extension, subject to the approval of the Air Force and the university, will not exceed 1 year. Appointment starting date and salary are negotiable.

The Air Force Systems Command/ National Research Council Resident Research Associateship Program

Under this program, postdoctoral scientists and engineers investigate problems of interest to the Air Force at sponsoring Air Force laboratories. Two types of awards are made, regular associateships and senior associateships. Persons who received their Ph.D. within the last 5 years may be awarded a regular research associateship. Senior research associateships may be awarded to those who received their Ph.D. more than 5 years earlier. Appointments are for 1 year, and renewable up to 3 years.

The National Security Agency's Summer College Outreach Program (SCORE)

This program is designed to offer summer employment to faculty members of the engineering, computer science, mathematics, sciences and other critical skill departments at historically black colleges and universities and selected schools with large Hispanic and Native American enrollments. While employing only a handful of professors each year, it is expected that this program will result in an increase in the full-time permanent employees hired from the institutions with whom the professors are affiliated.

RECRUITMENT PROGRAMS

Participation in Conferences, Job/Tech Fairs

The DoD Components made wide use of professional, technical and special emphasis program conferences, job fairs, science fairs, technical symposia, etc., to publicize their individual missions and job requirements, to distribute applications for employment, and to recruit, interview and hire candidates for science and technology occupations.

Advertising, Brochures and Publicity

DoD Components do extensive advertising in professional, technical and trade journals and in various job search publications. Many have prepared attractive brochures which depict their missions; latest "state of the art" types of weaponry and equipment; variety of professional and technical occupations; local community attractions, training, educational and development programs available; and various career options, such as dual career tracks for technical as well as managerial opportunities.

College Recruitment Programs

This incorporates a number of initiatives and serves as the principal vehicle for recruiting college graduates in scientific and technological fields. Employment staffs place a heavy emphasis on cultivating good relations with college and university officials and faculty through mail, telephone and personal contacts. The National Security Agency personnel representatives and technical representatives, including engineers, computer scientists and mathematicians, visit colleges and universities to give presentations, attend career fairs and interview applicants. Interviews take place directly on the campus.

These trips normally include a number of operational personnel and security interviews and testing. Schedules for campus visits, both for interviews and attendance at career fairs/symposia include Historically Black Colleges and Universities (HBCUs) and other campuses having high Hispanic, Native American and disabled persons enrollments.

The National Security Agency invites qualifying candidates to visit its headquarters at agency expense.

Computer Operations Associates Program

This program recruits students at local community colleges who are studying computer science/programming for part-time employment in computer operations, with the promise of full-time employment upon graduation with an associates degree. The National Security Agency has approximately 25 participants in this program.

Special Initiatives to Recruit Disabled Persons

As Executive Agent, the Department of the Navy, in conjunction with the Department of Defense, sponsors an annual Federal agency-wide conference for disabled persons.

In addition, the Department of the Navy conducts an extensive recruitment program for disabled persons to work in summer employment jobs as well as permanent positions within Navy and other DoD Components. The recruitment coordinator visits over 18 colleges and universities between November and March. In FY 88, more than 400 students were interviewed and 60 were hired by Navy activities. The applications were also shared with DoD Components and other Federal agencies in the metropolitan Washington, D.C., area.

An aggressive program at the David Taylor Naval Ship Research and Development Center for the hiring of disabled persons which includes a summer employment program for over 50 severely disabled college students. The students are hired into mission oriented positions. Accommodations for housing is coordinated by the Naval Research Laboratory, and transportation is provided to and from the work site.

The National Security Agency identifies and recruits high quality disabled candidates from a number of sources; i.e., special schools, conventions and advertising. Special arrangements are made regarding travel, hotel accommodations, testing and interviewing. Special initiatives include a direct approach to campus handicap coordinators to inform them of the employment needs and development of an experimental program, similar to the Co-op program, but specifically designed for disabled students majoring in critical skill fields. Specialized equipment is used to facilitate the assimilation of disabled persons into the work force.

Regional Recruitment Centers

The National Security Agency has maintained two regional recruitment offices in Atlanta and Boston for the past 8 years as a means of providing close relationships with the academic community in those areas. A third regional office is under consideration for the Southwest region of the United States, which will greatly enhance recruitment of Hispanics and Native Americans. The Southeastern Regional Office in Atlanta has been instrumental in increasing the agency's representation of minority campuses in that area.

Through Federal Executive Boards or locally established organizations such as Federal Equal Opportunity Recruitment Program (FEORP) Councils, the Department of the Navy activities have established Neighborhood Job Information Centers in Central and Southern California, and in Philadelphia. The job centers are typically located in areas with high minority populations. In addition to providing job information and testing, the centers provide career counseling, tutorial assistance and courses on how to complete an application for Federal employment.

Technical Speakers Program

The National Security Agency will provide upon request a number of technical speakers who present unclassified papers of technical merit to a variety of groups which are considered high potential recruitment sources. Although recruitment is not their primary mission, emphasis on technical opportunities is included in the presentation.

Research and Engineering Organization Mathematics Symposium

The National Security Agency sponsors this symposium to which mathematicians from around the country are invited to exchange ideas and present papers. Since many of the participants are also employed by institutions of higher education, it is hoped that they will present the agency as a possible employer to their students, although that is a secondary benefit of these symposia.

RETENTION PROGRAMS:
DEVELOPMENTAL OPPORTUNITIES FOR DOD CIVILIANS

The Upward Mobility Program

This program provides opportunities for employees who are GS-8 (wage grade equivalent) or below in dead-end type jobs to be cross-trained into other occupational series. Under this program, journeyman level positions may be restructured to entry level positions, whereby employees, who have competitively demonstrated potential and satisfactorily completed specified training plans, may move into new career fields with greater advancement opportunities.

The Secretary of the Army Science and Engineering Fellowships

The Secretary of the Army Science and Engineering Fellowships are designed to develop the talents and skills of Army employees who have a demonstrable record of technical achievement and leadership. These individuals compete for up to 12 months of full-time academic support that includes a research project on a technical issue of relevance to the Army mission. In this way, Army employees and university researchers develop a relationship that can be maintained after the employee's return to the job. Ten fellows were selected to participate in FY 87, and 4 in FY 88.

Civilian Scientists and Engineers Career Program

The Department of the Air Force has established a career program for civilian scientists and engineers (S&E). In order to advance the status of the civilian Science and Engineering Corps, Air Force has established a Policy Council for the Professional Enhancement of Civilian Scientists and Engineers. The policy council advocates for all S&Es and provides overall Air Force policy guidance and direction for the civilian S&E corps. Through its working panel and its various subcommittees, it plans to address the various concerns and problems confronting the scientific and technical community. Those areas that are being reviewed and studied include retention, recruitment, professional growth, productivity enhancements, professional identity, dual career tracks, performance appraisals, etc. The Council recently sponsored an Air Force policy letter on encouraging the use of dual career tracks for scientists and technologists.

Palace Acquire (PAQ) Interns

PAQ is an Air Force centrally funded and managed force-renewal program to attract and retain a cadre of high quality employees. PAQs are normally recent college graduates brought into entry-level positions. PAQs receive special training and developmental opportunities to prepare them to assume future management positions. A special incentive offered to science and technology PAQs is the ability to obtain a Master of Science degree during their trainee period.

Executive Leadership Programs

The Office of Personnel Management established an Executive Leadership Program. While men are not excluded, it is primarily targeted to provide training and developmental experiences for women in grades GS-9 through GS-12 in an effort to improve their competitiveness for key management positions. All defense components had an opportunity to submit nominees, and many nominated and funded attendance for employees. This program has been in existence since 1983. A total of 65 DoD employees are participating in the 1988 program; Army has 32, Navy 29, National Security Agency 3, and Defense Communications Agency 1.

The Department of Defense established an Executive Leadership Program for its components, which is now in its second year. It has graduated 90 participants, 21 Blacks, 2 Hispanics and no disabled persons. The program is in its third iteration with 47 participants, 3 Blacks, 1 Hispanic, and no disabled persons.

The Defense Mapping Agency established an Executive Leadership Program which affords a 1-year training and rotational assignment experience for high potential employees primarily at the GS-11 and 12 grade levels. Approximately 83 persons participated between 1986-1988 and 28 were recently selected for the 1989 iteration.

Mr. CIPOLLA. The Task Force found that the dramatic changes expected in the composition of the nation's labor force will have a direct impact on DOD's ability to meet its future staffing needs in scientific and technical fields. The Task Force projections show that even in a non-growth environment, DOD can reasonably expect to replace up to 10,000 scientific and technical personnel a year, civilian employees, due simply to turnover.

When turnover rates are coupled with the decline in the number of entrants to the work force, our recruitment and retention will be seriously affected.

Moreover, we're concerned, as are others, about the continuing erosion in federal pay and benefits which are going to further complicate our ability to compete effectively for scarce scientific and technical personnel with the private sector.

The Task Force recommended a series of immediate short range and long range actions for the Department to take to meet future needs in scientific, engineering and technological occupations. To assure that these actions are carried out, we have established a Science and Technology Work Force 2000 Project Management Office specifically for this purposes.

Among the actions which were recommended are—I'll summarize just a few, the first of which is chartering a Defense Science Board Task Force to review this entire issue and make recommendations for long term action. Among the matters to be examined is the possible establishment of an appropriate level Commission or long term advisory committee to the Secretary of Defense; development of a more precise analysis of DOD's scientific and technical staffing requirements through the year 2000 is needed and should be conducted; initiatives to assist current employees to obtain scientific and technical degrees, including proposed legislation to change current restrictions in the Government Employees Training Act, preventing agencies from financing degrees for employees.

And I'm pleased to say that as a result of our efforts in this regard that a bill has been supported by the Administration and has been forward to Congress for consideration, which will help meet those objectives.

DOD components, the military departments, and the defense agencies are to implement a systematic plan to expand science and engineering education intervention programs now conducted by the Department to meet future needs in scientific and technical occupations.

I understand that this Committee is especially interested in DOD's science and engineering related intervention programs, particularly those at the precollege and undergraduate levels. The Task Force review revealed that currently individual DOD components, especially the military departments, have a wide range of programs in place which are designed to replace and increase the pool of qualified scientific, engineering and technical skills.

The Task Force Report to which I referred previously includes a compendium of over 40 ongoing DOD programs that contribute to advancing scientific and technical education. These programs are summarized in the report's appendix in the logical sequence from precollege opportunities through postdoctoral programs.

Some of these programs, for example cooperative education experiences in DOD laboratories, use the standard Civil Service appointment authorities. Other programs are sponsored by the scientific research offices of the Army, Navy, and the Air Force.

The Army Research Office, the Office of Naval Research, and the Air Force Office of Scientific Research are the principal DOD supporters of basic research conducted at the nation's universities and, as such, for decades provided graduate students and young faculty members with opportunities such as fellowships and other sources of support in defense-related disciplines.

Approximately 8000 graduate students are annually supported under DOD scientific research contracts and grants to universities. During Fiscal Year 1989, DOD will directly support 568 graduate fellows in disciplines spanning the science and engineering spectrum including such fields as electrical engineering, oceanography, physics, and biotechnology.

On the other hand, we also recognize the importance of priming the pump. We have a variety of programs in place that stimulate interest in the sciences among precollege students. Our oldest is the Junior Science and Humanities Symposium established by the Army through its Research Office in 1958 and which today involves 8000 high school students each year in 46 regional symposia where students present research papers, hear distinguished scientists and participate in laboratory visits.

Our most effective programs are those that provide young people with hands-on research experiences. The largest of these is the DOD Science and Engineering Research Apprenticeship Program for High School Students. This was established in 1980 when fewer than 100 students were first placed as apprentices in about a half-dozen Army and Navy laboratories in the immediate Washington, D.C. area. This summer the program will place over 600 students in more than two dozen Army and Navy laboratories within the Washington, D.C. area alone. Hundreds more will work at Army, Navy and Air Force R&D laboratories located throughout the United States, and more than 300 will be placed with university scientists conducting research under DOD grants and contracts. In many locations throughout the country and particularly in the Army's university component of this activity, the program focuses on recruiting females and minorities and socially and economically disadvantaged youngsters.

Other programs targeted for these populations include the Uninitiated Introduction to Engineering program sponsored by the Army in which over 200 students each year receive special university-based instruction in science and math.

One of the activities our new project management office hopes to undertake in the coming year is an assessment of the effectiveness of our science and engineering education programs in order to provide guidance in establishing new programs and replacing or expanding our existing efforts. Unfortunately, at the current time, evidence of effectiveness is basically anecdotal, and we hope to obtain more concrete data through more sophisticated evaluation techniques.

In addition to the co-op program and summer hire activities, the major DOD support at the undergraduate level of education is focused on ROTC scholarships. In the early 1980s when it became clear that DOD would need increasing numbers of scientifically and technically trained military officers, the percentage of ROTC scholarships devoted to S&E students were measurably increased. Today 42 percent of the Army, 54 percent of the Navy and Marine Corps and 70 percent of the Air Force ROTC scholarships are devoted to students pursuing scientific or technical degrees.

While we believe that all of these efforts which I have summarized within DOD are commendable, it is recognized that we need to do much more with interventions because the Federal Government is going to become increasingly non- competitive in a diminishing labor market, at least through the next decades. We are committed to doing all that we can with this task.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Cipolla follows:]

STATEMENT BY

MR. FRANK P. CIPOLLA

DIRECTOR, PERSONNEL MANAGEMENT

(CIVILIAN PERSONNEL POLICY)

OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE

(FORCE MANAGEMENT AND PERSONNEL)

BEFORE THE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

FIRST SESSION, 101ST CONGRESS

DEPARTMENT OF DEFENSE ROLE
IN
IMPROVING SCIENCE AND MATHEMATICS EDUCATION

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MAY 24, 1989

Mr. Chairman and members of the Committee:

I am pleased to testify on behalf of the Department of Defense on our initiatives to strengthen science and engineering education. As you know, DoD's mission is to ensure a strong national defense. Our national defense strategy has long been based on using superior technology to counter our adversaries' numerical advantage. But, superior technology can only be developed and maintained by scientifically and technologically skilled people. Consequently, DoD has some special concerns about the current state of scientific and technical education at all levels, and how, along with expected demographic changes in the composition of the future labor force, it may affect DoD's ability to carry out its mission in future years.

The Department of Defense directly employs over 3 million people, 2 million active duty personnel and 1 million civilians. Of the 1 million civilians who work in DoD, approximately 100,000, or 10 percent of the civilian work force, are scientists and engineers. Of the 2 million active duty personnel, almost three-quarters of a million enlisted men and women are technicians and require a sound high school education in math and science. Beyond our direct employment needs, DoD spending affects approximately 14 percent of scientists and engineers employed in the nation's industries, and as you know, most of our contracts with private industry are for the development of some of the most sophisticated of "high technology" products.

DoD supports strengthening the nation's science and engineering education infrastructure because our educational institutions produce the personnel needed at all levels to maintain the United States' defense posture -- from the mathematically literate high school graduate who can make a technical contribution in the enlisted force, to the science or engineering Ph.D. candidate who conducts the basic research that may ultimately result in a technological innovation.

Current issues with possible serious implications for the nation's defense posture include poor elementary and secondary school preparation in science and math, and declining numbers of young people pursuing undergraduate and graduate scientific and technical degrees. These trends become even more alarming for the scientific and technical community at large, and DoD S&T needs in particular, when viewed in the context of the expected changes in the composition of the work force; while it is clear that DoD will have to rely more heavily in future years on women and minorities in its work force, it is discouraging that these groups are historically those most underrepresented in scientific and technical disciplines. Moreover, recent studies show that enrollments of these groups in S&E disciplines peaked in the early 80's and are now declining. This trend must be reversed if S&T fields in general and DoD S&T needs in particular are to have sufficient supplies of qualified personnel in the future. Increasing the supply of U.S. citizens in S&T disciplines is especially important to DoD for the reason that many of our programs require personnel with security clearances, and difficulties often arise in granting clearances to non-U.S. citizens.

DoD is actively addressing the very questions raised by the Committee. Recognizing both our needs for scientific and technical personnel, as well as the changes which are expected to occur by the turn of the century in the composition of the nation's labor force, former Secretary of Defense Frank Carlucci established in September, 1988, the Department of Defense Task Force on Human Resource Management in Science and Technology: Year 2000. This Task Force was a direct outgrowth of DoD's participation on the Congressionally mandated Task Force on Women, Minorities, and the Handicapped in Science and Technology established by Section 8 of Public Law 99-383.

Secretary Carlucci charged the DoD Task Force to study, report, and make recommendations on future DoD staffing needs in science and technology in light of the changing gender, ethnic, and racial composition of the labor force between now and the year 2000. The Task Force was also directed to bring about a focus on identifying and implementing intervention strategies and to pull together existing DoD interventions for dissemination throughout the Department in a systematic way to encourage replication by all Military Departments and Defense Agencies.

The Task Force report, which, with your permission, I would like to submit for the record, was prepared in the form of a White Paper for the Secretary. The Task Force found that the dramatic changes expected in the composition of the nation's labor force will have a direct impact on DoD's ability to meet its future staffing needs in scientific and technical fields. DoD will consequently find itself in serious competition with other Federal agencies and private employers to meet its work force requirements.

While additional analyses of personnel requirements are necessary, the Task Force projections show that even in a non-growth environment, DoD can reasonably expect to replace up to 10,000 S&T personnel a year due simply to turnover. When turnover rates are coupled with the decline in the number of entrants to the work force along with the projections of shortfalls in S&T personnel made by the Office of Technology Assessment and the Hudson Institute among others, both civilian and military recruitment and retention could be seriously affected. Moreover, the continuing erosion in federal pay and benefits will further exacerbate our inability to compete effectively for scarce S&T personnel with private industry. If these predictions prove to be correct, the result will be a degradation of DoD's ability to fulfill its national defense mission.

The Task Force acknowledged that additional analyses and data were required in the areas of program documentation, development of specialized cost models to better assess and evaluate costs, and identification and collection of centralized cost information. Recognizing these facts and understanding the magnitude of the problem, the Task Force recommended a series of immediate, short-range and long-range actions for DoD to take to meet future needs in scientific, engineering and technological occupations. To assure that these actions are carried out, we have established a Science and Technology Work Force 2000 Project Management Office for that purpose. Actions recommended include:

o Chartering a Defense Science Board Task Force to review this issue and make recommendations for long-term action. Among the matters to be examined is the possible establishment of an appropriate level Commission or long-term advisory committee to the Secretary of Defense.

o Conducting a more precise analysis of DoD's S&T manpower requirements through the year 2000.

o Initiatives to retain current employees in S&T occupations should be identified, including possible legislative changes to the existing personnel and pay systems to improve recruitment and retention of S&T personnel.

o Initiatives to assist current employees to obtain S&T degrees, including proposed legislation to change current restrictions in the Government Employees' Training Act preventing agencies from financing degrees for employees. A bill is currently pending before the Congress on this matter.

o DoD components are to implement a systematic plan to expand science and engineering education intervention programs now conducted by the Department to meet future needs in S&T occupations. Consistent with demographic projections, intervention efforts are to target women, minorities, and disabled persons.

I understand that this Committee is especially interested in DoD's scientific and engineering related intervention programs, particularly those at the precollege and undergraduate levels. The Task Force review revealed that currently individual DoD components have a wide range of programs in place which are designed to replace and increase the pool of personnel qualified in scientific, engineering and technical skills. The Task Force report, which I referred to previously, includes a compendium of over 40 ongoing DoD programs that contribute to advancing scientific and technical education.

These programs are summarized in the Report's Appendix in logical sequence from precollege opportunities through postdoctoral programs. Some of these programs, for example cooperative education experiences in DoD laboratories, use standard Civil Service appointment authorities. Other programs are sponsored by the scientific research offices of the Army, Navy and Air Force.

The Army Research Office, the Office of Naval Research and the Air Force Office of Scientific Research are the principal DoD supporters of basic research conducted at the nation's universities, and as such, have for decades provided graduate students and young faculty members with opportunities such as fellowships and other sources of support in defense-related disciplines. These programs are designed to ensure that we have sufficient advanced degree personnel in our own laboratories, industry and universities necessary for carrying out cutting-edge research and development in critical defense disciplines and technologies. Approximately 8,000 graduate students are annually supported under DoD scientific research contracts and grants to universities. During FY 89, DoD will directly support 568 graduate fellows in disciplines spanning the science and engineering spectrum including such fields as electrical engineering, oceanography, physics and biotechnology.

On the other hand, we also recognize the importance of "priming the pump," for there will be no advanced degree candidates unless students in elementary and secondary schools are stimulated to pursue a scientific or technical undergraduate course of study.

We have a variety of programs in place that stimulate interest in the sciences among precollege students. Our oldest is the Junior Science and Humanities Symposium established by the Army Research Office in 1958 and which today involves 8,000 high school students each year in 46 regional symposia where students present research papers, hear distinguished scientists and participate in laboratory visits.

Of all the programs summarized in the Task Force Report, however, perhaps our most effective are those that provide young people with hands-on research experiences. The largest of these is the DoD Science and Engineering Research Apprenticeship Program for High School Students. Established in 1980 when fewer than 100 students were first placed as apprentices in about a half-dozen Army and Navy laboratories in the immediate Washington, D.C. area, this summer the program will place over 600 students in more than two dozen Army and Navy laboratories in the Washington, D.C. metropolitan area alone. Hundreds more will work at Army, Navy, and Air Force R&D laboratories located throughout the United States, and more than 300 will be placed with university scientists conducting research under DoD grants and contracts. In many locations throughout the country and particularly in the Army's university component of this activity, the program focuses on recruiting females and minorities and socially and economically disadvantaged youngsters. Other programs targeted for these populations include the Uninitiated Introduction to Engineering (UNITE) program sponsored by the Army in which over 200 students each year receive special university-based instruction in science and math.

These programs, together with co-op education opportunities that provide students with hands-on research experiences appear to be most successful in motivating young people to pursue scientific and technical disciplines. For example, a study of recruitment and retention among scientists and engineers in DoD laboratories found that 50 percent of all co-op students converted to full-time after graduation, and 80 percent of those who convert stay at least three years.

One of the activities the new project management office hopes to undertake over the coming year is an assessment of the effectiveness of our science and engineering education programs in order to provide guidance in establishing new programs and replicating or expanding existing efforts. Unfortunately, at the current time, evidence of effectiveness is principally anecdotal; we hope to obtain more concrete data through evaluation techniques.

In addition to the co-op program and summer hire activities, the major DoD support at the undergraduate level of education is focused on ROTC scholarships. In the early 1980's when it became clear that DoD would need increasing numbers of scientifically and technically trained military officers, the percentages of ROTC scholarships devoted to S&E students were measurably increased. Today, 42 percent of the Army, 54 percent of the Navy/Marine Corps and 70 percent of Air Force ROTC scholarships are devoted to students pursuing scientific or technical degrees.

The Military Services have established mechanisms for broadly advertising opportunities for participation in their programs from precollege through postdoctoral. The Services and DoD laboratories also coordinate their activities with each other and with both private and public sector science education initiatives. DoD also coordinates with other federal science agencies and organizations such as the National Academies of Science and Engineering, and participates in a variety of activities including the National Research Council Government-University-Industry Research Roundtable in which science and engineering education issues and programs are discussed. The Department has also been an enthusiastic participant in the Congressionally mandated Task Force on Women, Minorities and the Handicapped in Science and Technology. The former Deputy Assistant Secretary of Defense for Civilian Personnel Policy, Ms. Claire E. Freeman, who is now at HUD, was a key player on this Task Force and the catalyst for current DoD-wide activities.

While we believe current DoD efforts and programs are commendable, it is recognized that more needs to be done with interventions because the Federal Government will become increasingly non-competitive in a diminishing labor market, at least through the year 2000. Consequently, all DoD components are being asked to have in place by the end of this year a systematic plan to expand their current intervention programs. In addition to an aggressive approach to intervention programs, efforts will be made to increase the representation of those groups historically underrepresentated in science and engineering careers, i.e., women, minorities and persons with disabilities.

In closing, as former Secretary Carlucci stated in establishing the DoD Task Force on Human Resource Management in Science and Technology: Year 2000, "the Nation and its leadership have a responsibility to assure that we recruit, train and advance a sufficient supply of fully qualified personnel to carry out our mission of defense for peace." DoD is committed to that task.

The CHAIRMAN. Thank you, gentlemen. Questions?

The gentleman from Texas.

Mr. HALL. Thank you, Mr. Chairman.

I guess my first question would be directed to Mr. Cipolla:

I agree with you that our defense status is based on superior technologies. I know you are probably aware of the fact that the rank of file of the people across this country really wonder if we are abreast of other countries in the world in these technologies. We've seen Sputnik beat us into space; we've seen Japan robotize their assembly lines long before we did; we hear frightening statistics that for every four little children who start school one falls by the wayside before they get through high school and that—that's not happening in other countries. Inasmuch as we're the country that in the late-Forties and early Fifties had the greatest, I guess, economic superiority and geopolitical strength in any country in the world, it seems to me it's slipping away from us.

I just wonder if we have enough brainpower, either in the pipelines or on the production lines, to offset these statistics, and, I'd like your comment on the statistics because I know, whether it's true or not, the fact that it's believed by the masses is of concern to you in the leadership position you're in.

Mr. CIPOLLA. Well you've said much more eloquently than I can what the condition is and what the perception of many individuals in this country is about our ability to compete and to, in fact, upgrade the kinds of technological and scientific skills that we need.

Some of those studies have been done, but I don't believe that there is a dissenting voice anywhere on the observation that you've made. Clearly we in DOD believe that we have to move, we have to move quickly and we have to try. This is why we put this package together. It is why we did it at the time we did—which was at the end of the last Administration and in an effort to bring to the attention of the new Administration, our new Secretary and our new leadership, exactly how many intelligent people felt about the kinds of concerns that you have expressed.

So we're hopeful that with this—the impetus that comes from this we can get some better answers to the questions and the perceptions—

The CHAIRMAN. Will the gentleman yield for a moment?

Mr. HALL. I do yield.

The CHAIRMAN. Has Secretary Cheney reviewed this recommendation yet?

Mr. CIPOLLA. It has been presented to him. The idea, as I say, was for him to have the opportunity to review it, determine whether this was the course that he wanted to follow or to modify it in some respect. We are waiting for his guidance. We fully expect that the priority will be as we've outlined in this document. There may be some variations in how we approach the individual aspects of it.

Mr. HALL. I'd like to inquire of Dr. Moore, too—we've talked and you've heard the other testimony here before this panel, panel number one, the Admiral, and my inquiry of him about industry, the participation of industry and tapping that as a resource.

It seems to me that since industry has such a very large stake in the production of new scientists and engineers, I just wonder if NSF has—what they've done to attempt to attract industrial support, leverage some of your funding of educational programs. There is a benefit to these industries, as you pointed out, in that they, you know, are spawning their own future engineers and brainpower because the students probably leave there with the help of that industry and want to come back.

I just wonder if there are other incentives that ought to be out there, incentives such as tax credits or a priority on bidding on defense contracts or whether or not they should have such. What are your feelings on that, Dr. Moore?

Dr. Moore. I agree fully with your general premise, and that is that industry should be involved very deeply in what we're going to do. They do have a very strong interest in this.

And by the way, just one remark on that score. There's a lot of attention being directed at educational reform. Of course, these days I am rather optimistic about the chances for success in this regard exactly for the reason that I believe that industry and also the states and localities are clearly recognizing their self-interest in doing that. And I think that with that kind of interest there and the proper leadership that this job will get done.

I do believe, by the way, with respect to your previous question, that we do have the brainpower. We're just not using it. We're not developing it. We're not using it properly and that's what we need to do.

Mr. Hall. Brainpower costs money.

Dr. Moore. Brainpower costs money, that's true. We do have a number of initiatives at NSF that are designed to attract industrial participation both financially and intellectually—which is almost as important as the financial aspect.

We have a program called Private Sector Initiatives, which is designed to bring the expertise of industry, the practical experience of industrial scientists and engineers and businesspeople into the design materials for use in the schools, so that science is brought to a practical level that is readily understandable by the students.

I mentioned, I believe, in my oral statement the Publishers Initiative. That directly involves publishers from the very beginning of materials involved with projects.

At the other end of the educational pipeline, as I were, the Presidential Young Investigators program provides for matching funds for industrial support of these very bright and promising young academic researchers. And we have had quite good luck in attracting industrial support to that program. About 70 percent of the maximum amount has in fact been provided.

There is very widespread industrial participation in NSF programs in general. We have recently completed a study of our own programs to assess that and our best estimate is that we are leveraging our funds at about $300 million a year in industrial support of various kinds, both cash and equipment and contributed time by industrial researchers.

This bringing of industrial personnel and resources into our university programs, I think, is going a long way to meet the kind of objective that you have in mind.

One last remark. You mentioned taxes. We have long supported the R&D tax credit, which we think if made permanent and if modified in the right way structurally, could be a very important incentive indeed. And we would like to see that done.

Mr. HALL. Thank you.

Mr. Chairman, I just have one other question.

The CHAIRMAN. Would you yield at that point for a second?

Mr. HALL. Yes.

The CHAIRMAN. Let me offer an apology for this Committee. There's 50 members of this Committee, and I regret that there aren't more of them here. Unfortunately, there's 10,000 things going on at one time, as you're probably aware. And I assure you that as of today this Chairman is going to change the method of holding public hearings because it's ludicrous to waste time of five or seven highly-trained people and important executives in this Administration, or any Administration, and not have the chance for people to benefit from the exchange of views. So I wanted to make that declaration to begin with.

The second thing I'd like to make the comment on:

You know, you've been listening, you've been following—not only today, this is a whole series of hearings—if the gentleman would yield further—and the thing that puzzles me, as an academic layman having served 21 years on this body—the thing that puzzles me is we all understand the problem.

If you listen to the testimony carefully—Admiral Watkins this morning, plus yesterday's testimony and so forth—we have a serious lack of educated teachers that can teach science and technology. That has been a given; everybody has spoken to that issue.

It seems to me someplace you've got to educate the teacher or somebody has got to set up something that educates the teacher. The assumption that this is going to happen by osmosis to me is absolutely sheer poppycock, as far as I'm concerned.

And we come back and we say to ourselves the textbooks are antiquated. You know, so much is happening in NASA, so much is happening in NSF and in agriculture and in NIH, particularly, I'm thinking of biotechnology, and certainly in the military, that the technology itself is running faster than the members of Congress can keep up with it. And I'm sure faster than the Departments can keep up with it. Why in God's name would we be using antiquated—or should there not be some thread at least of some very basics that ought to be taught?

Now we get to the point in the testimony yesterday where they came back and said, well no, we don't do it that way. It is better to let it be at the local level. Let the local people decide what kind of curriculum we can have.

And I can take you to my town, and our former town, of Wayne and if we took—and I love the people dearly. They are highly educated. They are wonderfully motivated; but, if you were to sit down and talk to them about the science and technology involved in the space program, their eyes would glaze over. And surely they would glaze over if you talked about biotechnology and the work that is being done in that particular field. So textbooks to me become an extra- ordinarily important part of it; at least some kind of a teaching aid, I would think.

One other point—and pardon my getting carried away—is the issue that how, if everything is going so well and we have pilot programs and whatever, how do we get down into the local, the lower levels and say that as a national policy, not as a local determination—God forgive me for saying this—but as a national policy we ought to be teaching science, space and technology in the first grade. Everybody has spoken to that.

There's not a witness that has not testified in the last few days hasn't made that observation, including Admiral Watkins, and I'm sure the Secretary of Education would. The question is—and we're not going to spend any money, that's okay—the question to me, unless I'm a total idiot, how are we going to direct that? Let it happen by osmosis? It is just going to occur? You don't really believe that, and I certainly don't believe that.

So I would hope that out of these hearings—and I don't mean this as any admonition to anyone that's testified today because you're probably as frustrated as I am. But it seems to me what we're looking for is a policy direction the country chooses to go. And in order for a policy direction for the country to choose to go, we've got to establish the guidelines that we want.

The assumption that we're going to train 1000 teachers, and that's going to solve the problem in this country is absolute lunacy. It's not going to happen that way. It's got to be on a much greater base.

And one more point: if the numbers of students are dropping off materially as they are, both in the lower levels and particularly in our universities and we're going to be in competition in defense and we're going to be in competition in what we're talking about, particularly in NASA, the high-technology areas, and certainly in the advanced work of NIH, then where are we going to get the biochemists and the biotechnologists and where are we going to get the engineers to do that work and what is it going to cost us?

You made the point earlier that we can't even begin to sustain the people that were in government because you can't pay them and won't pay them enough money. And therefore they're going to be able to go out in private industry, and you're not even going to get anyone to come in government to try to do the work that has to be done.

Having made that admonition, I will defer back to the distinguished gentleman from Texas.

[Laughter.]

I'd like to see some answers to some of those questions.

Mr. Hall. I've forgotten what I wanted to ask.

The Chairman. Go ahead.

Mr. Hall. I've almost forgotten what I wanted to ask, Mr. Chairman.

[Laughter.]

Mr. Hall. I think, Dr. Wyngaarden and perhaps Dr. Hess, you talked about the students and how many that you'd trained. And I just wonder—you know, we get letters here telling us how to vote. And then they drop a paragraph in there saying, and I'm going to watch the records and see if you do.

So do you all track to see how many of these youngsters that do pursue science majors in college that you have accommodated in the lesser grades? Do you have a method to do that? And would it be beneficial to?

Dr. WYNGAARDEN. Mr. Hall, we have done that perhaps most systematically with the MARC program. We have good records on what these students select. These are college-level students who are in an enrichment program in science opportunities. And a fairly high percentage of those students actually go on to earn doctorate degrees or other advanced degrees in the sciences. Some of them were in research; many of them are in the professions; but at least they are utilizing that science-based education to go forward.

Mr. HALL. I do thank you.

Thank you, Mr. Chairman, I yield back my time.

The CHAIRMAN. The Chair recognizes the gentleman from Iowa.

Mr. NAGLE. I want to pick up on something you said, Mr. Cipolla, about the bill that you'd introduced to permit the educational enhancement and training of current employees. And it frankly kind of caught me by surprise. You mean that there are—please educate me—are there restrictions now in terms of a government employee wanting to go out and move from a Masters to a Ph.D.?

Mr. CIPOLLA. There are not restrictions in taking courses that lead to a degree. The problem is that courses have to be justified on a course-by-course basis, and the justification has to be job-related or somehow career- related. It's done ad hoc, course-by-course.

What we have attempted to do—

Mr. NAGLE. Pardon me, just for a second.

First of all, is that criteria true, Dr. Brown, Dr. Moore, Dr. Hess and Dr. Wyngaarden, of your agencies, too?

[Witnesses nodding affirmatively.]

Mr. CIPOLLA. This is in the Government Employees Training Act, which applies—

Dr. HESS. Yes.

Mr. NAGLE. Is the answer affirmative on that?

Mr. CIPOLLA. Yes.

So what we hope to do with that proposed legislation is allow for reimbursement for degrees, undergraduate and graduate degrees, up front in total rather than having to piecemeal it and justify it on a course-by-course basis.

We can then use that as a recruitment incentive, as the private sector does.

Mr. NAGLE. I'm kind of shocked that it hasn't been done before, frankly.

Do you know the number of that, H.R. something? Do you have the number of the bill?

Mr. CIPOLLA. It hasn't been introduced yet. It was just sent over from OMB just last month, late last month.

Mr. NAGLE. Could I get a copy of it when it's ready? Would you see that I get a copy of it.

Dr. Brown?

Dr. BROWN. I wonder if I could just—I'm not sure that this falls precisely in the same category, but one of the areas that we have been very interested in is the number of scientists and engineers within NASA and within the aerospace industry who are interested in making a second career in teaching.

Most of them realize that it is important to get certification to teach, in addition to their technical expertise. There are some problems that have to be confronted, and one of which is getting administrative leave to get the kind of training that is required; payment for courses that are required to prepare oneself. Then with respect to our existing tax code, if employees are pursuing training that is not directly related to their immediate employment, then they get no tax allowance for that.

Mr. Nagle. They have to finance it with their own money?

Dr. Brown. Yes, they do.

Mr. Nagle. Is that true across the board, everybody? I mean, if you want to—if I'm sitting there with a Mh.D. in physics and I want to get a Ph.D, I have to get, first of all, approval and then secondly I have to pay for it—

[Witnesses nodding affirmatively.]

Mr. Nagle.—if I'm a government employee?

Dr. Brown. If it is not related to the particular work that one is doing, his or her basic career.

Mr. Nagle. If it is related to the work that they're doing, do we pay for them to enhance their education?

Mr. Cipolla. If it is related, that's part of the justification process that I mentioned, then we can reimburse, but course-by-course.

Mr. Nagle. Just a generic observation, if I may. We are currently wrapped up in the Bureau of the Ethics, and we're focusing quite a bit on government employees. And we are experiencing a rather mass exodus of government employees at NASA, at, I suspect, at DOD, probably DOE and the others. And to my mind we're moving in the wrong direction. I mean, we ought to make government the best place to work, not the hardest place to work. We ought to try to get the best employees, and we ought to try to keep them. And this whole focus on how do you prevent or punish people for going through the revolving door could be answered if you made it more attractive not even to contemplate that door.

And that would mean that we get rid of our antiquated pay scales. That would mean if you have a problem in terms of continuing education that we address that aggressively and quickly. And that we actually take a different approach than what we have as a Congress in terms of this whole question of revolving door as a conflict of interest by making it more attractive for you to stay in your positions and your employees to stay in your positions than we're currently doing.

So if you've got a bill moving in that direction and that's a problem, I'd be very, very interested for any one of you or all of you to send any comments or recommendations that you have.

I think it's crazy. We've waged war on each other for eight years, and I think it's time we reversed that and made it a matter of pride to work for the Federal Government and a matter of attractiveness to work for the Federal Government.

Does anybody disagree with that?

[Witnesses nodding negatively.]

Dr. Moore. Not at all.

Mr. Nagle. Speaking of church, there would be some amens and hallelujahs.

Thank you.

The Chairman. Well I think the gentleman—before we break up, I think the gentleman raises a very important issue and I know you've worked hard on your testimony—let me say this, if you can stand a little bit of humor.

I remember when I first testified before Congress when I came down in the cabinet in New Jersey, and I prepared the testimony for four or five days. I really worked at it because I thought it made a difference. And it was very important to me that that testimony would be delivered, and at least there would be somebody to listen to what I had to say.

When we testified, we were before a little bit of an ad hoc group, I guess, of the Congress, and they said well put your statement in the record and, you know, just sum it up in two—we'll give you two minutes to sum it up and so on.

And I was mad as hell as a citizen because I worked to prepare that. Because what was the point in having the testimony, it didn't go anyplace.

So I want to get that point across. Don't think that your testimony will not be reviewed or is not being understood. It is, by far.

Let me make one other comment. I think Mr. Nagle is striking at a very good point, and it might be something you'd want to take back to the Administration rather than have it as a fiat from up here.

It would seem to me that the testimony we've heard, the purpose of this hearing—and indulge me a moment—the purpose of this hearing is to review the educational leg of the species we have developed in creating the new wealth for America, that America is going to need down the road. Science, space, technology and education is that foundation. If we seriously short the research work, for example, in NIH, the work you are doing in biotechnology particularly, if we short that area, then we are shorting all of the opportunities for the advances we can make in medicine and so forth.

If we do it in NASA—we almost lost the space station the other day, as you know, when they wanted to cut that $523 million out—we lose not just the space station, we lose the space program, is really what it amounts to.

If we talk about agriculture, whether we sold some grain to—and supported the grain that went to the Soviets—there was a broader based policy issue for that. But it's the fact that we were able to produce the food in the first place.

As far as the military is concerned, the cutbacks—we don't want to lose the NASP program. Not that it's the end of the world, but it would be very important to us from a technology point of view vis-a-vis the point of composite materials and all of the other great work and the motor work and the engine work—motor work that's going on there is very important.

And we go to the National Science Foundation, that is the foundation of where all of our people are going to be educated, at least the—we are in a peer review, what do we do here and there.

But it would seem to me that we ought to be in the position of looking across the board and saying to ourselves, what is the potential impact upon the Federal Government in just the points that Mr. Nagle is making?

I'm not just talking about salaries and so forth. Where are you going to get the personnel properly trained five—not 50 years—five years from today to be able to fill the middle management and run the order of magnitude of the departments you're responsible for? Where is that going to come from? It's not going to come out of interns here and interns there. And I don't say that disrespectfully to any of your testimony.

I would hope that we can frame, after these hearings, more specifics now and come back and say how about this issue, what do we do with that issue and what kind of a policy do we make?

If we don't establish some policy at this level vis-a- vis the point of view of what happened when Sputnik went off, we're just going to limp along and nothing is going to get achieved, in my honest-to-God opinion unless we start directing those resources where they're going to do the greatest amount of good, which is going to be to make a national policy in science and technology and move in that direction.

Dr. Brown?

Dr. BROWN. Mr. Roe, I appreciate your remarks, and, if you would permit, I'd like to just comment on a couple of points that you made earlier which were quite sobering with respect to the textbooks.

We all know that typically the time from which new knowledge appears in printed text form and then is available in the educational system is five to seven years. And I haven't run into anyone who has been able to compress that time.

What we do in NASA is develop a series of aerospace education publications which we can usually produce in a seven- to eight-month period of time and make that available to teachers around the country. And literally our aerospace education publications run out of supply—they are best sellers at the Government Printing Office. And we think that's an excellent way of expediting the process of getting the material into the community.

The second point, with respect to teachers in general—I've been at NASA for going on four years now. All of my life I've been exposed to educators and the teaching profession. And I think that sometimes we may not fully do them justice. Many are very frustrated with pay and recognition and other kinds of problems.

But I must say, when we deal with educators in the context of NASA and aerospace, they are uniformly excited, enthusiastic. They take their contagion back to the classroom, and they motivate students.

We have the long duration satellite that's up, as you know—it's been up for five years. We hope that we can bring it back before the end of the year. We've got 12 million Rutgers tomato seeds on there—

[Laughter.]

The CHAIRMAN. I was reading about that. And I'm going to count them to see that all 12 million come back.

[Laughter.]

Dr. BROWN. And we've got 110,000 teachers around the country who have signed up to participate in that program for those seeds, and, hopefully, we can bring them back to look at the chlorophyll count and germination rates and other factors. And so we do find that the nature of our business is a strong motivational force with teachers, and we want to continue to do that.

The CHAIRMAN. Dr. Hess?

Dr. HESS. Mr. Chairman, one technical point in view of the comments that you made about your first testimony, I failed to mention that I had some more detailed testimony which I have submitted. So, I'd like to have them included in the record.

The CHAIRMAN. It will be included in the record, without objection. So ordered.

Any further comment?

Dr. HESS. I do certainly agree with your concern about the teachers. I believe they are a key—and I want to just mention one thing that we've done at the University of California at Davis in the past five years is to have during the summertime programs in which the science teachers come to Davis and are brought up to speed in terms of agricultural biotechnology.

We do this because of the great excitement there is in that science, and we think we can excite some young people into that area. It also gets them exposed to agriculture and the potential uses of the new technology in agriculture. And that has been a very, very popular program, and one that which I think will not only upgrade the teachers but increase our ability to attract bright young minds into this important area. And so I support that view you mentioned.

The CHAIRMAN. Okay. Any other comments?

[No response.]

I want to thank you all very much for joining with us today. It has been very productive, and we appreciate your help.

The Committee stands adjourned.

[Whereupon, at 1:05 p.m., the Committee meeting was adjourned.]

SCIENCE AND MATHEMATICS EDUCATION

WEDNESDAY, JUNE 7, 1989

House of Representatives,
Committee on Science, Space, and Technology,
Washington, D. C.

The committee met, pursuant to call, at 10:05 a.m., in Room 2318, Rayburn House Office Building, the Honorable Robert A. Roe, Chairman.

Mr. Walgren. [presiding] Well, let me call us to order, and welcome you all to our hearing today.

This is the third in a series of hearings on science and math education conducted by the Committee on Science, Space, and Technology. This morning, we have an enthusiastic and a really innovative and exciting group of witnesses who will tell us about specific programs that they have been involved in to increase student interest and to improve performance in science education, as well as improving teacher interest and teacher skills and teacher effectiveness.

We have demonstrations of some of the computer-based, interactive learning equipment and methods that we'll have at the conclusion of the testimony. And I'd like to ask, in the hopes of getting this hearing up and running, if members would not submit opening statements for the record, and that will get us to the point where we can have some discussion among people a little bit more quickly.

We will take all of the witnesses as one panel, and I would like to ask you each to go through your testimony and then we'll be able to have some discussion among all of us, which I think will be the best way to do this.

I know Mr. Campbell would like to introduce Mr. Stebbins, and as a tradition that we welcome, the chair would recognize Mr. Campbell.

Mr. Campbell. Thank you, Mr. Chairman. You are a most courteous and gracious chair.

I do wish to introduce Mr. Barry Stebbins, who is a biology teacher from Columbus, Ohio, and two of his students, who Mr. Stebbins will introduce. And the reason I'm asking to do so, Mr. Chairman, is because Mr. Stebbins has been working with the Apple Classroom of Tomorrow in a most innovative integration between high technology and education process. Apple Computer, as you know, is headquartered in my home district, in Cupertino, California.

Apple not only is working in the high school area, as, for example, with Mr. Stebbins, who has the only high school in the world integrated in this fashion with computer learning technology through the Apple system, but also a grade school project in Cupertino, California.

The Apple Classroom of Tomorrow reflects Apple's serious commitment to educational reform. It is a long-term research partnership between teachers, schools, education researchers, developers of computer hardware and software that examines how the computer technology can help educate children and prepare them for the 21st century.

I thank the chairman for his special accommodation, and I look forward to the demonstrations that Mr. Stebbins, his students, and the other witnesses will be presenting to us.

Mr. WALGREN. Thank you very much.

If there are no protests, that is the way we'll—go right to the witnesses at that point.

We have this morning and I'll—I want to introduce you for the record, but then as you give your individual testimony if you would identify yourselves for the reporter as well at that point, and any other context you would like to give.

This morning we have Charles Howarth, who is the Executive Director of the Sci-Tech Center, from New Jersey; Mr. Fred Easter, who is the Statewide Director of the Lawrence Hall of Science, from Berkeley, California, the University of California there; John Layman, from the Department of Physics at the University of Maryland; David Pysnik, from Sidney High School, in New York State; Mr. Pysnik is accompanied by Kerri Shea and Joe Suriano; and we have also Sylvia Ware, who is the Director of the Education Division, American Chemical Society; and, as Mr. Campbell has said, Barry Stebbins, from West High School in Columbus, Ohio, accompanied by Sadi Chhoa and Mittie Cheatham. I apologize if I mispronounce names. And that's a part of the problem.

All right. Well, let's start with Mr. Howarth, and we will go through the witnesses in as direct order as we can.

Mr. Howarth?

STATEMENTS OF CHARLES HOWARTH, EXECUTIVE DIRECTOR, SCI-TECH CENTER, JERSEY CITY, NEW JERSEY; FRED EASTER, STATEWIDE DIRECTOR, LAWRENCE HALL OF SCIENCE, UNIVERSITY OF CALIFORNIA, BERKELEY, CALIFORNIA; JOHN LAYMAN, PH.D., DEPARTMENT OF PHYSICS, UNIVERSITY OF MARYLAND, COLLEGE PARK, MARYLAND; DAVID PYSNIK, SIDNEY HIGH SCHOOL, SIDNEY, NEW YORK, ACCOMPANIED BY KERRI SHEA AND JOSEPH SURIANO; SYLVIA WARE, DIRECTOR, EDUCATION DIVISION, AMERICAN CHEMICAL SOCIETY, WASHINGTON, D.C.; AND BARRY STEBBINS, WEST HIGH SCHOOL, COLUMBUS, OHIO, ACCOMPANIED BY SADI CHHOA AND MITTIE CHEATHAM

Mr. HOWARTH. Thank you very much, Mr. Chairman, and members of the committee. It's a pleasure to be here this morning to talk with you about science programs that work, and I'd particularly like to spend a few minutes with you talking about museum education and its potential role in helping to address problems in science literacy.

My own background is I'm the director of a developing museum, a major one, that will be located near the Statue of Liberty, in Jersey City, New Jersey. It's called Sci-Tech Center and it's got an interesting history. It's really a perfect example of a public-private initiative.

This particular museum, or science center, as many of us are beginning to call ourselves, grew out of a concern, primarily in the corporate sector, about the inability to hire well-trained, well-educated, American young people to fill jobs in their—at all levels in their corporations. The organizations behind the project hit upon the idea of a science museum as a way to leverage and to build the coalition to do something about that problem, and our supporters include organizations such as Warner-Lambert, Johnson & Johnson, AT&T, Eastman-Kodak, and 75 other major corporations of New Jersey and New York in partnership with the State of New Jersey. A $46 million project, 10 of which is State funding, and the balance is private and largely corporate.

So it's really a very exciting project. In fact, President Bush in a recent speech identified it as a prime example of a public-private initiative for the furtherance of public education.

Now, why a new museum? I'd like to, very briefly, touch on several strengths that museum educators can bring in working with the schools and in working with the public. My own project will be, as you will understand, built on the experience of other institutions nationally in cities across the country; and, consequently, much of what I might mention is from other communities, although I have already begun in New Jersey to do outreach programs and I will mention a couple of those in passing.

I'd like to start with the issue of working with the schools and teacher training. This is a major—I think, perhaps, a surprisingly major role for museums, one that is not widely known. The Association of Science Technology Centers reports, for example, that in 1986 science centers reached 47,000 teachers in in-service training, all in the sciences, much of it at the elementary level. Clearly, these institutions are at the forefront in that area.

And I think the reasons are, first, that museums are non-threatening. They are user-friendly institutions, if you wish. They are fun places to go to, and the elementary teachers in many cases are people who are not comfortable with science; consequently, they find a hands-on science museum an inviting way to get some help and some support in an environment that they know will respond to their needs.

The programs, the 47,000 teachers that I mentioned, many of these are intensive and ongoing. We're not necessarily talking only about a workshop in how to use the museum as a resource, although we do that too. But some of the programs that we have been involved with in the museums that I've worked at include month-long residential programs for teachers or 16-week courses in computer education or perhaps most excitingly, programs that take place entirely out in the community rather than at the museum itself.

We've run, when I was up in Boston at the museum there, a program that went out into low income communities around the area and really provided intensive support for teachers, including being there whenever the teacher needed help. We would send the staff out. We would do teacher training. We provided materials. Had an 800 hotline in case the teachers got in trouble and the experiment didn't work the way it was supposed to, so that you could get a quick turnaround and find out what went wrong.

And it's clearly a style of education that works. When the teachers try it, they like it. We have anecdotally experience that suggests that—these are inner city teachers that we're talking about. That these teachers comment very, very enthusiastic about the potential of science in their classroom because the kids like it, it's fun, it's hands on, it's interactive, and it allows them not only to teach science better, but to teach everything better. A major role for museums, and I'd be happy to discuss that further with you during questioning.

A second major role for museums is direct programming for children, and here I would stress the need to start early. We feel that by junior high school statistically only 23 percent of our young people still express an interest in science, and so high school is too late. We can't wait until they get to high school and then try to convince them that, yes, you really would like to take high school chemistry, because it isn't going to work. We've got to get them in the elementary school, and here this happens fortuitously, to be a natural constituency for science museums and science centers. The children come in large numbers. The attendance at many of these institutions runs in the several hundreds of thousand schoolchildren per year.

But, in addition, large parts of the programming that science centers offer is offsite, in the community again. In fact, fully one-third of all programming for schoolchildren offered by science museums isn't at the museum at all, but in the community. And I think our demonstrated effectiveness, just one example of that, the Pacific Science Center, in Seattle, has a program that puts science on the road in a van. They drive around the State, set up in the school auditorium, and offer classes, workshops, and exhibits right there. And the program has been so successful that the State has put $2.3 million of State money into it over the next biennium for the purpose of expanding that even further and reaching even larger numbers of children.

I think for children the emphasis that I would place is that these science centers are motivating environments. Kids like to go to the museum. The publication "A Nation At Risk", which is, I guess, really what kicked off a lot of the present concern, noted that, although by junior high school most children no longer express interest in science, they like science as presented in museums, zoos, science centers, and aquaria; and, consequently, there is an opportunity for us as museum educators to leverage what schools are doing, working in partnership to provide these young people the reason. Here is why it is worth taking those courses. Sure it is hard work, but it is fun, too.

A third major audience for museums, which I think is critically important, is parents. Museums—and when I use that term I am speaking broadly again of zoos and aquaria and other institutions of that sort—are virtually the only social learning environment that society offers. The only place where groups of people learn together and where they can stand around an exhibit and share in the experience.

From the point of view of parents, we know that 95 percent of the adult population is scientifically illiterate, uncomfortable with science, untrained in science—and consequently, although it is clear that parents want to be involved in their children's education, and although they feel the need to help, they don't have in many cases the tools to do it. Come to a museum, here is a chance for the child and parent to work together in a setting that sets the parent up to be the natural leader and the educator.

An example of that: We know statistically that children don't read labels in museums. The parents do. The parent, while the kid is playing, cranking the crank, light bulb lights up, the parent is reading the label to understand why that happens, and then is able to help the child to understand, which creates an opportunity for parents to become involved in their own children's education, and, in fact, to let their children know the importance that they place on it. And we think that this is one of the few places that that happens.

So, yes, families watch television together, but it is a passive experience for the most part. Yes, you can read a book with your child. But to really explore together, the opportunities are all too rare.

And finally, I might mention briefly the role of museums in minority education. There is a growing concern in my business to get the groups that traditionally have not participated and are not participating fully in science and to work with them. You will be hearing more about that later—the Project MESA, from the Lawrence Hall of Science, which is a science center. But it is a very important area for us. And I would assert that the sort of hands-on cooperative learning environment that museums offer has been demonstrated to be particularly effective with disadvantaged populations.

I think, Mr. Chairman, that I've used my 10 minutes, and I will stop there and thank the committee very much for the opportunity.

[The prepared statement of Mr. Howarth follows:]

SCI·TECH CENTER
at Liberty State Park

870 Bergen Avenue
Jersey City, New Jersey 07306
201-795-9155

Remarks of:
Charles H. Howarth, Jr.
Executive Director
Sci–Tech Center
June 7, 1989

Before the

Committee on
Science, Space
and Technology

House of Representatives
101st Congress

SCIENCE EDUCATION: WHAT WORKS

In Jersey City, N.J., children watch as a computer records their voices in digital code and then translates them back into vocal sound. With squeals of delight, they jostle for position to be the next to experiment. Then on to other displays, which reveal the mysteries of fiber optics or the history of telecommunications, all in a "hands-on" format. All available slots to visit this exhibit have been booked for weeks ahead. Teachers bringing classes have an opportunity to participate in a workshop that provides them with follow-up activities for back at school — everything from taking apart a telephone to building a simple telegraph.

This exhibit is the maiden effort of a developing institution, Sci-Tech Center, which will soon join the ranks of science centers across the country in providing educational resources to schools and public visitors. It's a style of education that works: hands-on and minds-on, motivating, exciting, and just plain fun. Children love visiting these centers, and teachers do, too. As a museum educator, I'd like to explore the increasingly important role that science centers and museums can play in addressing the nation's crisis in science literacy.

Over the past two decades, science museums have redefined their relationship to the schools and the community, offering programs that are jointly developed with local school systems to meet the fundamental needs of the classroom teacher. Today's museums are powerhouses of education, offering a wide variety of programs and services to schools, parents, and children. To reflect this new emphasis on education, many museums no longer call themselves that at all but have come to be known as science centers.

Sci-Tech Center, my own institution, is not yet open, but our experience provides some useful insights into what science centers are all about and their potential impact on the community. The idea for Sci-Tech Center grew out of a concern in New Jersey's corporate community about the lack of quality science education in the schools. The corporate scientists see these problems directly when they hire new staff. At one end of the spectrum, an increasingly high percentage of corporate research scientists are foreign citizens; at the other, entry level technicians are so hard to find that most corporations train their own. The corporate community is also deeply concerned about national competitiveness.

As a result of these concerns, an organization called the New Jersey Research and Development Council commissioned a comprehensive study of what might be done to improve science education, and out of that study grew the project now known as Sci-Tech Center: a major new museum of science and technology scheduled to open in 1992 in a state park in the shadow of the Statue of Liberty. This $46 million project has been funded largely by corporate contributions--$25 million to date--and by $10 million from the State of New Jersey. President Bush has described the effort as an outstanding example of a public-private partnership for the furtherance of public education. The Center will focus on topics of special interest or importance to the general public: health science, environment, air and space, and technology.

The R & D Council was convinced that a science museum is a way to contribute to public science literacy. The outstanding programs already in place at similar institutions across the United States serve as ready models for Sci-Tech Center and other similar institutions popping up across the country.

Four key areas in which the museum community has a proven capacity to play a leadership role are:

- in-service training of teachers;
- programming for elementary-aged children;
- support for parents in their role as educators for their children; and
- programming to reach minorities and other groups that are not participating fully in science.

IN-SERVICE TRAINING FOR TEACHERS

> "I didn't have any problems. Just one. The kids didn't want to do anything but science. Even the worst students were the best in science. I couldn't get them out of the room. They stayed with me 'til three o'clock each afternoon and then I couldn't get them out. The noise would go up, the kids got carried away. When we were doing electricity they didn't want to go off electricity, the same with plants. They had trouble giving the things back to the Museum."
>
> — inner-city teacher

In many communities, science centers are major providers of in-service training in science for teachers. The Association of Science-Technology Centers in Washington reports that, in 1986 alone, teacher training programs in one hundred science centers served over 47,000 teachers. The need for training is particularly acute at the elementary level, where many teachers are untrained in and uncomfortable with science. Science centers are particularly effective at reaching this group because the centers are non-threatening, "user-friendly" institutions; and because the centers feature "hands-on" education, a technique of proven effectiveness. When teachers try it, they like the results.

Boston's Museum of Science, my former institution, offered training to 2300 teachers in 1986, including an intensive month-long residential seminar funded by NSF, a sixteen week computer education course, and a program of support for elementary teachers that takes place entirely in the classroom. The latter program provides teachers with the materials they need to make science exciting: batteries and bulbs to build simple circuits, skeletons, fossils, mineral specimens, computer software, books, games, and puzzles. More important, the program provides teachers with needed support and training, even including an 800 "hot line" to call when things go wrong. This program targeted low-income communities with little or no budget for science texts, materials, activities, or field trips. The quote above is from a participant.

Nor is Massachusetts unique. The Franklin Institute provides materials and training to teachers throughout the Philadelphia school system. Berkeley's Lawrence Hall of Science has been a leader in national curriculum projects for three decades. Smaller science centers frequently play a similar role. The Thames Science Center has been invited by a school superintendent to design activity-based curricular materials for elementary schools in New London, CT.

Emulating these efforts, Sci-Tech Center has already begun its own teacher training programs, reaching 450 teachers last year even before our facility is complete.

PROGRAMS FOR CHILDREN

A very clear lesson of all of the recent studies of science education is that we need to reach children at a much earlier age than we are doing at present. High school is already too late. Most elementary school children receive very little instruction in science, and what they do get is largely based on reading a text, even although we have known since the sixties that "hands-on" instruction is far more effective. As a result, by junior high school, only 23% of our children still express an interest in science, and most of these are white males.

Museums do much to address this particular problem. Just as children learn sports not only in P.E. class but also through Little League or Pop Warner, so museums offer an opportunity to participate in science — to play the game in an exciting and involving setting that complements classroom learning. Indeed, A Nation At Risk, the seminal report that triggered much of the current concern about science literacy, noted that the same children who deny an interest in science at school participate eagerly when the subject is presented in museums.

Dr. Jon Miller of Northern Illinois University, a leading expert on scientific literacy, makes this point:

> Everyone who has worked in a museum setting or has watched elementary schoolchildren in certain exhibits knows about the stimulation of curiosity, excitement, wonder, and awe. Likewise, anyone who has taken the bus ride from museum back to school knows that a day in a science museum generates far more questions than answers, more curiosity than understanding. This is no small achievement. Despite the billions of dollars invested in formal education, school science and mathematics programs have not been successful in stimulating genuine interest in these topics.

What is the secret to this success, this ability to ignite enthusiasm for science and math? Simply that science centers encourage exploration, exposing children to real objects and real experiences. Museums deal exclusively in learning by doing, and in self-directed discovery--a style that is closer to real science than the lecture and rote learning of too many classrooms.

Another strength of museum education is a capacity to help children develop an intuitive grasp of science at an early age. In the Soviet Union, children as early as second grade receive an hour a week of "intuitive" physics and geometry, meaning that the emphasis isn't on mathematics but on phenomena. Over a period of years, very gradually the children learn the visual vocabulary of science. By the time they reach the stage of complex quantitative equations, they need only learn to apply mathematics to concepts that they already understand intuitively.

Our students, by contrast, are launched into theoretical physics without a solid grounding in the underlying phenomena. Only the very brightest students are able to make that mental leap, and as a result physics becomes a specialized subject for a small minority of our population.

Science centers strive to provide perceptual experiences in science by allowing visitors to have direct exposure to physical phenomena and real objects.

The list of successful science center programs for children is lengthy. One example that is rapidly growing in popularity is the Camp-In program that originated at the Center of Science and Industry in Columbus, Ohio, and has now spread to many other museums. In a typical Camp-In, Girl Scouts or other youth groups spend a Saturday night "camping out" in sleeping bags among the museum's interactive exhibits. They are turned loose on bicycle gyroscopes, hair-raising Van de Graaff generators, wave tanks, lightning machines, walk-in kaleidoscopes, laser and planetarium shows, dinosaur bone puzzles, chemistry demonstrations and cow's eye dissections.

Pacific Science Center's Science on Wheels takes educational programs and exhibits out to schools across the state. Science on Wheels has proved so successful that the State of Washington has recently allocated $2.3 million for the next biennium in support of this effort. Fully one-third of all science center programs for schools similarly take place on an outreach basis, at the school rather than at the center, an indication of the importance the centers place on support for the formal education system.

PARENTS AND CHILDREN

Museums offer another strength that is unique: they encourage family learning. At museums, parents and children learn together. Adults are far more likely than children to read labels on exhibits, with the result that parents are able to act as leaders and teachers to their children. Most parents are eager to participate in their children's education, and most recognize the importance of science, but many are themselves "science shy" and don't know where to begin. Museums can provide the support they need.

The parents' role in sharing in the excitement of learning is extremely important. Studies comparing Asian to American education have focused on support at home as one key variable. When asked what factor is most important for success in school, mothers in Japan and Taiwan typically answered, "hard work", while American mothers reported, "natural ability", suggesting that the former expect (and get) more from their children than the latter.

Learning together is an extremely effective way for parents to express the value they place on sound education, and science centers particularly encourage such behavior.

A proven example is Family Math, a program of the Lawrence Hall of Science in Berkeley. Family Math trains elementary teachers to offer hands-on mathematics classes for parents with their children. This highly successful program is another that has been widely disseminated throughout the museum community and beyond.

MUSEUMS AND MINORITIES

Many science centers are addressing the critical problem of increasing minority participation in science. Theodore Bredderman of SUNY-Albany has found that "hands-on" activities are especially effective in reaching students from disadvantaged backgrounds. It is precisely this "hands-on" approach that science centers emphasize.

The Science Museum of Connecticut is one particularly good example of a successful program for minorities, launched with help from the National Action Council for Minorities in Engineering (NACME). With NACME support, the museum succeeded in developing a coalition of school systems, major corporations, universities, and state government to tackle the problem of increasing minority enrollment in science. Program participants, almost entirely minorities, are drawn from grades 6 through 12. Activities range from mentoring to tutoring, special classes, visits to scientific facilities, and summer residence programs at distinguished universities. Typical is a Robotics Course at the Museum, where middle school students spend ten Saturdays designing and constructing small robots that perform useful functions. Projects have the secondary objective of helping students develop self-esteem, which is crucial to the learning process.

And the results are impressive! In operation only three years, the program has expanded to three major school districts in Connecticut, with other cities clamoring to participate. Early indications are that the program will result in a significant increase in the number of students continuing their education in science and math at four-year institutions. One young woman, who prior to participating had given little thought even to attending college, has now been accepted at MIT's summer program, preliminary to being accepted at that institution.

Former NACME president Richard Neblett explains the reason for his interest in collaborating with science centers: "They can arouse the interest. They can, working with our local programs, help sustain that interest until that pool becomes sufficiently large to affect college enrollment, college success, and college graduation."

SCIENCE MUSEUMS: THE FEDERAL ROLE

These programs are just a brief sampling of the rich resource that science centers offer to their communities. These and similar programs provide outstanding models on which new institutions such as my own can build. Science museums are a close knit community where good ideas spread rapidly. Yet, given sufficient resources, these museums could accomplish far more than at present. There are two ways in which this goal could be achieved.

Support for new museums

Despite the fact that science centers are invaluable educational resources, many communities across the country are unserved or underserved by one of these institutions. Public demand has resulted in rapid growth of existing centers and the founding of many new ones. The Association of Science-Technology Centers is in contact with over 60 groups that are planning new science centers. These community efforts are supported primarily by private sources and some local public funds.

Rather than having each new museum develop its own exhibits and education programs entirely from scratch, the government should encourage dissemination of model programs from well established museums. This could be accomplished through a grant program dedicated to replicating the best of what is already out there, an approach that is both cost-effective and educationally sound.

The federal government plays no role in providing capital financing for new science centers. The National Endowments for the Humanities and for the Arts have competitive Challenge Grant programs targeted to serve existing art and humanities institutions. (Each federal dollar requires a three- or fourfold private match.) A similar challenge grant program designed to strengthen new and existing science centers would provide enormous leverage in encouraging local fundraising efforts.

NSF has already shown an interest in supporting new science centers through a grant to the Association of Science-Technology Centers for the purpose of running a summer institute for professionals new to the field who are planning new museums. However, the two-year grant will expire at the conclusion of this July's ASTC Institute for New Science Centers.

Support for exhibits and education programs

The single most important source of federal funding for science museum programs is NSF's Informal Science Education Program. The program has stimulated and nurtured numerous innovative, high-quality projects through highly competitive matching grants. The money is well spent and yields substantial results. Nevertheless, the total amount of funding available is small: only $15 million this year, to be shared among museums, public television, and other informal educators. The museums' share of this allocation is less than half—this to serve the needs of science centers, zoos, aquaria, and similar institutions. In addition, new and developing institutions are ineligible to apply.

Increased funding for this program would yield educational innovations of broad benefit within and without the museum community, and would allow science centers and museums more fully to realize their potential in service to the community. Federal support, which leverages extensive local and private financing, could go a long way to make these institutions even more effective than they already are.

Mr. Walgren. Let me thank you, Mr. Howarth, for that. And we'll go on to the other witnesses and then come back for some discussion.

I should have said at the outset that your written statements will be made part of the record that's developed here and worked with by those who work with testimony. And that will be part of the record upon submission, and you can feel free, as Mr. Howarth has, to underscore points that they would like to stand out in the transcript of the verbal proceedings as well.

And, without objection, the committee will give permission for any photography or other kinds of recording of these proceedings that people might be interested in making.

So, with that, know that you can feel free to underscore and focus on points that you would like to have stand out from the written record in your oral testimony, and the written testimony will be reproduced in that part of the record for that purpose.

Well, with that let's turn, then, to Dr. Easter.

Mr. Easter. One correction, Mr. Chairman. I am not a doctor of any type.

Mr. Walgren. Okay. Fair enough.

Mr. Easter. And I am the statewide director of MESA—Mathematics, Engineering, Science Achievement—housed in the Lawrence Hall of Science on the campus of the University of California.

On behalf of the hundreds of people, paid and volunteer, in industry and education, whose tireless efforts earn MESA its reputation for success, I would like to thank this committee for its invitation to testify.

MESA began nearly 20 years ago when a professor of engineering, Wilbur Somerton, became distressed at the paucity of black students who found their way into Berkeley's School of Engineering. With startling good sense for a university professor, he questioned high school teachers to learn the reason. One math teacher at Oakland Technical High School, Mary Perry Smith, felt that if teachers worked with promising math and science students the way coaches work with promising athletes, the city of Oakland would produce as many successful engineers as it does professional athletes. They struck a bargain. She identified promising students, steered them to the right courses, tutored them when they had problems, and informed and encouraged their parents to help keep those kids on track. He arranged class trips to labs, manufacturing sites, CADCAM facilities, and the like. He also arranged for black scientists and engineers to visit her MESA meetings to talk about what they do at work and how they came from where those kids are through their college careers to their current positions.

The model worked. Today, over 200 such coaches work with over 5,000 African, Mexican, and Native American youngsters in high schools, and now middle schools as well. Eighteen MESA precollege directors support those coaches by interfacing with industry volunteers, arranging for curriculum enhancement seminars for teachers; and tutoring sessions, SAT workshops on Saturday, and summer academies for students. Annually, we hold competitions, regionally in design, mathematics, speech, spelling, model car, rocketry. These MESA Day competitions, held in both Southern and Northern California, are exciting and fun for students, and give them an opportunity to meet and mix with hundreds of other students who share their passion for academic pursuits. The importance of this student networking can't be underestimated because our target students are also daily treated to the example of drug-pushing fellow students in cars, who out-earn their teachers and their principals.

At the college level, we have 18 support retention programs called MEP—Minority Engineering Programs—replicating the model designed by Dr. Ray Landis at Cal-State Northridge over 10 years ago. We support over 3,000 students with campus orientation classes, clustered registration, calculus workshops, scholarships, summer jobs, internships, counseling, mentoring, and tutoring.

We evaluate the program's process by maintaining an extensive data base on each of our students from the time they join us, through the grades to college and their first job. We monitor the courses they attempt, the grades they earn, college preferences for secondary school students, SAT attempts and scores, cost per student per school, and a variety of other management tools.

In addition, the California Post-Secondary Education Commission conducts formal evaluations of segments of our programs, almost continually, for the State legislature. It is currently conducting an evaluation of our middle school program. Its most recent look at the college-level program appeared in early 1987, and in 1988 a study of our governance system was published.

We know, for example, that virtually 100 percent of our seniors graduate from high school; 90 percent enter 4-year, post-secondary institutions; 67 percent of those declare a math-based major. At the college level, the persistence rate of our students exceeds that of Angloes and equals that of Asians in California schools of engineering and computer science. We are in touch with hundreds of our alumni who now hold important positions in aerospace, petrochemical, communications, software, and other industries key to our national defense.

The MESA program has been successfully replicated wholly or in part in a number of States: Washington, Oregon, Arizona, New Mexico, Colorado, Missouri, Kansas, Nebraska, are examples. Mr. Bernard Charles of the Carnegie Corporation has been instrumental in urging State legislatures to follow California's lead in funding programs like ours. For our part at MESA, we are a willing co-conspirator to any effort to improve the math knowledge base of our target students anywhere in the United States.

To date, the Federal Government has played only a minor role in supporting the programs I know most about. United States corporations, foundations, and State legislatures, each by themselves have had far greater impact on the seeding, support and replication of this initiative; though I would be remiss if not mentioning that the United States Navy, Air Force, Aerospace and Space Administration, and the CIA cooperate with us, particularly at the college level, as though they were corporations, by supporting our competitions and college employment fairs.

Successful though we are, our efforts are small when viewed against the backdrop of California's population and paltry when compared to the magnitude of the problem. If the government would match the State of California's contribution to our efforts, it would enable us to more than double the number of students with which we work. If it were to match American industries' support of our work, we could more than triple the number of students with which we work.

Thank you.

[The prepared statement of Mr. Easter follows:]

Mathematics,
Engineering,
Science
Achievement

The California MESA Program
(Mathematics, Engineering, Science Achievement)

EXECUTIVE SUMMARY

Submitted for Hearings on Math and Science Education
Committee on Science, Space and Technology
U.S. House of Representatives
Room 2318, Rayburn House Office Building
June 7, 1989

Lawrence Hall of Science
University of California
Berkeley, Ca. 94720
415/642-5064

The California MESA Program
EXECUTIVE SUMMARY

Table of Contents

Introduction and General Program Data 1

Pre-College Achievements 2

Minority Engineering Program Achievements 3

Factors That Contribute to MESA's Success

General 4

Pre-College 4

Minority Engineering Program 5

Evaluation

External... 6

Internal 7

Replication of MESA Model Outside California 7

Organization 8

History 8

APPENDICES

Board of Directors

Industry Advisory Board

Campus Locations

Pre-College Outreach Brochure

Industry Outreach Brochure

California College Pipeline: MESA and Other California Students

MESA: Decade of Progress

The California MESA Program: Comments From Participants and Supporters

"When I began my studies, I was one of three Black women in engineering, so you can imagine how it felt to look around me and see virtually no one else in my own image. I think that the Minority Engineering Program gave me the important opportunity to work with other ethnic students and to celebrate who we are.

"Some students look at programs geared to minority students and stay away from them because they figure the program must be remedial. But MEP is not remedial; it challenges students to meet high academic standards. It can be the difference between failure and success."

Michelle DeCoteau
Rhodes Scholar, University of California at Berkeley
Graduate, MESA Minority Engineering Program

"The two most significant competitive advantages any company can develop are technology and people. The MESA Program plays an invaluable role in bringing these two together and in tapping the pool of students who will become the scientists and engineers of the future."

John A. Young
President and Chief Executive Officer
Hewlett Packard Company

"I personally support the whole MESA concept. It's a good model of partnership between industry and education. We've got a tremendous opportunity in California if we can get these students prepared. That's why programs like MESA are so important."

Bill Honig
Superintendent of Public Instruction
State of California

"ARCO has supported MESA for 17 years—because it works. We see MESA as a good business investment for ourselves and for the State of California."

Lodwrick M. Cook
Chairman and Chief Executive Officer
ARCO

1. INTRODUCTION

The mission of the California MESA Program (Mathematics, Engineering, Science Achievement) is to increase the number of historically underrepresented ethnic students who graduate from a four-year college with a degree in computer science, engineering or other math-based major. MESA's target groups are African American, Mexican American, Puerto Rican and American Indian students.

The MESA Program began in 1970 in Oakland, CA, and currently operates through colleges of engineering on 23 state and private campuses throughout California. MESA is a program of the University of California at Berkeley, with statewide administrative offices at the Lawrence Hall of Science on the campus. Dr. Marjorie Gardner, Director of the Lawrence Hall of Science, is MESA's principal investigator.

Through its pre-college program and its university program (the Minority Engineering Program, or "MEP"), MESA provides a continuum of academic support and guidance services from seventh grade through graduation from college.

2. GENERAL PROGRAM DATA

- MESA serves 8,000 students, including 5,000 in junior and senior high school, and 3,000 at the university level.

- MESA administers 16 pre-college centers, housed in colleges of engineering on University of California, California State University and private campuses. These centers service 135 high schools and 45 junior high schools, located in 51 school districts.

- MESA provides Minority Engineering Programs (MEP) for university students on 18 University of California, California State University and private campuses.

- Some 200 public school teachers serve as MESA Advisors at their schools.

- More than 200 alumni have volunteered for service to MESA.

- Seventy leading California and national corporations support MESA with in-kind and direct financial contributions. Historically, corporations and foundations have provided 50% of MESA's funding.

- The annual operating budget for MESA programs statewide is about $5 million.

- The MESA model has been used for development of similar programs in at least ten other states; MESA California has provided technical assistance to six of these.

3. PRE-COLLEGE PROGRAM ACHIEVEMENTS

- The pre-college program served about 4,800 students in 1987-88.
- Nearly 8 in 10 (75.9%) of MESA's 1987 graduating class enrolled in college the following fall; this compares to about 50% of all California high school graduates.
- From 1983 to 1987, 4,632 MESA participants graduated from high school. Through its tracking efforts, MESA has records of 62% of these graduates. Of those accounted for, 96.5% were either enrolled in college as of fall, 1987, or had already received their degree.
- Scholastic Aptitude Test (SAT) scores for MESA students exceed both the California and national averages of their college bound peers. Furthermore, these test scores are not simply a function of above-average students enrolling in MESA; SAT math scores of MESA participants are significantly higher that the math scores for the PSAT that they took as sophomores or juniors.

4. MINORITY ENGINEERING PROGRAM (MEP) ACHIEVEMENTS

- MEP served 3,006 university students in 1987-88, an increase of more than 20% over the preceding year.
- MEP students are three to four times more likely than their non-MEP peers to persist in engineering studies for three years; the retention rate for MEP students (60%) equals or exceeds that of engineering students in all other ethnic groups.
- MEP students are highly successful, in spite of factors that might be obstacles to academic achievement.
  - MEP participants are predominantly (60%) from families where the parents have had 12 or fewer years of formal education. In addition, if they were not MESA participants in high school, their preparation for highly competitive math-based majors is often not sufficient (80% have had trigonometry, but only 56% have had physics).
  - Despite the above obstacles, nearly two-thirds (63.3%) of all students enrolled in MEP as of fall, 1987, have graduated or are still in engineering. This retention rate equals or exceeds all other ethnic groups. By contrast, 80% of all Black and Mexican American engineering students not in MEP drop out.
- Between 1983 (when MEP began) and 1989, more than 1,000 MEP students graduated with math-based degrees. (Note: MEP is still young; 1988 was the first year that we produced graduates who had spent all of their college career in MEP.)

5. FACTORS THAT CONTRIBUTE TO MESA'S SUCCESS

General:

. The conviction that historically underrepresented ethnic students can excel in math-based college majors; the commitment to help them meet high academic standards.

. Commitment to involve all cooperating players in planning stages of MESA programs; to get "buy-in" based on understanding of a mutually beneficial partnership among public schools, higher education and the private sector:

- Public schools benefit from material resources and professional expertise contributed by industry and higher education.
- Higher education and industry benefit from well prepared students and employees.
- Industry provides education with specialized knowledge of trends in technology and labor markets, which can inform curriculum development.
- Society as a whole benefits socially and economically from the development of an educated citizenry that is prepared to contribute to business and community.

. MESA's 38 fulltime, paid field staff members, whose sole function is to meet MESA program goals for underrepresented students.

. Clear definition of scope of MESA goals; MESA does not attempt to address the broader institutional issues of public schools or universities.

Pre-College:

Services

1. Academic Advising
2. Organized Study
3. Career Exploration
4. Scholarship Incentive Awards
5. MESA Meetings
6. Summer Enrichment
7. Family Involvement

- Early identification (sixth or seventh grade) of students with math aptitude and/or interest.
- Daily contact between MESA teachers and students to provide academic direction and catch problems early.

(continued)

FACTORS THAT CONTRIBUTE TO MESA'S SUCCESS/Pre-College (cont.)

- High academic and personal expectations of MESA students. The goal is regular admission to college in a math-based major (often the most rigorous and competitive majors).
- Redirection of mid-track students with math aptitude into college preparatory track.
- Cost-effectiveness through use of existing public school resources; cost sharing based on conceptual buy-in from districts, principals.
- Industry involvement in career exploration, tutoring and mentoring.
- Involvement of role models in direct contact with MESA students; ethnic engineers and scientists, professors and university students serve as guest speakers, conduct tours of industry sites and serve as academic facilitators and mentors.
- Acceleration and enrichment of academic skills through such activities as SAT workshops, Saturday academies, MESA Day academic and engineering competitions, and summer programs.
- Demystification of college admission through orientations to admissions and financial aid, conducted for students and parents. Students take field trips to college campuses.
- Enhancement of math and science teaching skills and curriculum through teacher workshops in hands-on projects for students.

Minority Engineering Program:

Services

1. Recruitment and Admission Activities
2. Freshman Year Orientation
3. Counseling Services
4. MEP Study Center and Academic Workshops
5. Support of Minority Student Organizations
6. Career Development and Summer Jobs
7. Financial Aid and Scholarships

- Location of program in academic department.
  - Academic deans and assistant deans serve as faculty sponsors. MEP is breaking ground in introducing engineering faculty to the majority student population of the coming decades. MEP provides the opportunity for these faculty to play leadership roles on their campuses in developing curriculum and counseling to meet these students' needs.
  (continued)

FACTORS THAT CONTRIBUTE TO MESA'S SUCCESS/MEP (cont.):

. All aspects of MEP students' campus life--academic, financial and personal--are centered in one location, rather than in a variety of administrative offices.

- Establishment of a community of underrepresented ethnic scholars within the college of engineering and campus.

  . Promotes students' focus on academic achievement by lessening feelings of social and cultural isolation.

  . Builds habits of group study and mutual support, and promotes the integration of students' academic and social life.

- Sets high academic standards through freshman year academic workshops in chemistry and calculus (the workshop goals are A's in both classes); sets strong academic foundation early.

- Promotes professional development

  . Industry and academic professionals provide training in research methods, resume writing, job interviews, and other work related skills.

  . Engineering related summer employment with industry.

  . Research assistantships with college professors as an orientation to academic careers.

- Promotes cooperation among all minority engineering groups on campus, resulting in a stronger voice for ethnic student concerns, a centralized organizational structure for contacts with industry and other outside groups, and cost-effective use of time and resources to support the academic and professional development of ethnic students.

- Special access to scholarships from industry and other sources, alleviating pressures that result from working while going to school.

6. EVALUATION

External:

. Because of MESA's professional approach and insistence on efficiency and effectiveness, the program has been rated one of the most successful of its kind in California and the nation.

(continued)

6. EVALUATION/External (cont.):

- Numerous independent evaluations have provided evidence of success:
  - California Postsecondary Education Commission (CPEC) random survey in 1981 of 100 California high school principals and senior counselors resulted in MESA being identified as one of the most effective, non-duplicative and substantial support programs.
  - CPEC reports to the California Legislature in 1981-82 and 1982-83 on efficiency and effectiveness of traditional and special outreach and support programs ranked MESA as one of the best, most efficiently run programs in the state.
  - A research institute of UCLA, commissioned by the Hewlett Foundation, conducted an external evaluation of MESA for the 1982-83 academic year. This rigorous study concluded that: 1) MESA was increasing the pool of target students eligible for math-based college majors; 2) MESA was increasing the number of target students graduating from high school and enrolling in a university; 3) MESA had a positive impact on the curricula and course offerings in participating high schools; and 4) MESA services were provided in a cost-effective, programmatically efficient manner.
  - A 1986 CPEC report on the retention of engineering students in California colleges presented impressive data on MESA's Minority Engineering Program, and recommended that MEP be established and supported in all California colleges of engineering. Among noted MEP accomplishments were: 1) MEP students were three-to-four times more likely than their non-MEP peers to persist in engineering studies for three years; 2) the three-year retention rate for MEP students was 60%, 13% higher than the retention rate (47%) for all engineering students (based on data gathered from University of California campuses).

Internal:

- MESA maintains an ongoing formative and summative evaluation process, with a computer stored file for every MESA participant. The file contains information on nearly 300 data elements about the participant, including such items as grade-point average, academic units completed, frequency of participation in MESA activities, results of standardized tests, and others.
- Through its evaluation procedures, MESA is able to track performance and standing on a variety of program variables.
  - For either the entire universe of MESA students or a sample of participants, our internal evaluation system can provide (continued)

6. EVALUATION/Internal (cont.):

specific data regarding status and progress on all major MESA goals and objectives (e.g., increasing the pool of target students who graduate from high school prepared for a math-based college major, increasing the college-going rate of target students, increasing the persistence rate of target college students, etc.)

- MESA's internal evaluation system has been recognized by the California Postsecondary Education Commission (CPEC) as one of the most comprehensive in use by such programs.

7. REPLICATION OF MESA MODEL OUTSIDE OF CALIFORNIA

- The California MESA model has served as the basis for establishment of similar academic support programs in Washington, Oregon, Arizona, New Mexico, Colorado, New York, Maryland, and several Midwestern states.
- California MESA provided direct technical assistance in the establishment of programs based on the MESA model, in Washington, Oregon, New Mexico, Arizona, Colorado and New York.
- Replication of the MESA Minority Engineering Program (MEP) model by other academic departments on MEP campuses is further confirmation of its effectiveness. In many cases, MEP Directors serve as technical consultants for such intra-campus replication of the MEP model. The College of Science on the Cal Poly Pomona campus is an example of one such non-engineering department that has adopted the model.

8. HISTORY

- The MESA concept was jointly created in 1968-69 by Dr. Wilbur Somerton, an engineering professor at the University of California at Berkeley, his colleagues on the Berkeley campus and at the Lawrence Hall of Science, personnel from the State Department of Education, industry representatives, and Mary Perry Smith, a mathematics teacher at Oakland Technical High School in Oakland, CA.
- The immediate concern to which MESA founders responded was the lack of African American, Mexican American and American Indian engineering graduates, who were increasingly in demand by industry.

(continued)

- The first pre-college program began in 1970 at Oakland Technical High School, with Mary Perry Smith serving as the first MESA Advisor. The program expanded from the Bay Area to a statewide effort in 1977. The Minority Engineering Program (MEP) for university students was begun in 1983, and the junior high school program in 1984.

- MESA is administered by a Statewide Office, housed at the University of California at Berkeley. It is served by a Chancellor's Advisory Board, comprised of representatives of industry, higher education and the public schools.

- A statewide Industry Advisory Board, comprised of representatives of the executive vice-president level of major California and national corporations, was established by MESA in 1978.

MESA Board of Directors

Chair:

Dr. Richard E. Pesqueira
Executive Director
Western Regional Office
The College Board
San Jose, CA

First Vice-Chair:

Mr. Rod Hanks
Director
Human Resources
Lockheed California Corporation
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University of California

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University of California at Berkeley

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The Achievement Council
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Northwestern Region
IBM Corporation
San Francisco, CA

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Director
[illegible] Department of Employment
Development
Sacramento, CA

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California State University, Los Angeles

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Executive Director
Center for Academic Interinstitutional
Programs
Graduate School of Education
University of California at Los Angeles

Dr. Joseph P. Linscomb
Deputy Superintendent
Instruction
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College of Engineering
University of California at Berkeley

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San Ramon, CA

Ms. Mary Perry Smith
Oakland, CA

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Deputy Superintendent
Specialized Programs
State Department of Education
Sacramento, CA

Mr. S. Dwight Wheeler
Vice President
Human Resources
Litton Guidance & Control Systems
Woodland Hills, CA

Personnel

MESA Statewide

Principal Investigator
Dr. Marjorie Gardner
Director
Lawrence Hall of Science
University of California at Berkeley

Chair, Board of Directors
Dr. Richard Pesqueira
Executive Director, Western Regional Office
The College Board

Chair, Industry Advisory Board
Mr. C.H. Mackdanz
Vice President
Industrial Relations
Chevron U.S.A.

Chair, Industry Technical Advisory Committee
Dr. David Morse
Director
Employee Placement
Pacific Bell/Pacific Telesis

Staff

Wilfred O. Easter, *Statewide Director*
Richard T. Santee, PhD, *Deputy Director*
Timothy D. Kelly, *Statewide Program Director, Loaned Executive, Pacific Gas & Electric*
Julian Zaragoza, *Associate Program Director*
Tempie Beaman, *Regional Director, Orange County/South*
Antonio Garcia, *Regional Director, Central*
Shelby Givens, *Regional Director, Bay Area/North*
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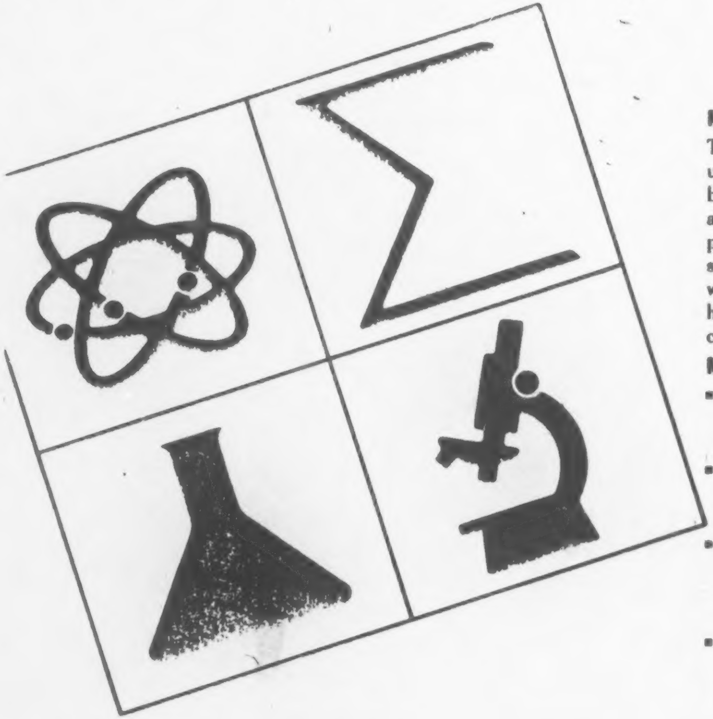
Linda Broatch, *Communications Officer*
Gay Nichols, *Fiscal Officer*
Carol Fields, *Research Associate*
Ethel Perkins-Mayo, *Administrative Assistant*
Jewel Turner, *Senior Coder, Research*
Dianne Carol Johnson, *Secretary*
Barbara Voinar, *Secretary*
Robin Wilson, *Secretary*

MESA Campus Centers

Pre-College Program ▲
University Program ●

NORTH		
California State University (CSU), Chico		●
CSU Sacramento	▲	●
San Francisco State University	▲	●
San Jose State University	▲	●
Stanford University	▲	
University of California (UC), Berkeley	▲	●
UC Davis		●
CENTRAL		
CSU, Bakersfield	▲	
Cal Poly San Luis Obispo		●
CSU Fresno	▲	●
UC Santa Barbara	▲	●
SOUTH		
Cal Poly Pomona		●
CSU Fullerton	▲	●
CSU Long Beach	▲	●
CSU Los Angeles	▲	●
CSU Northridge	▲	●
Harvey Mudd College	▲	
Loyola Marymount University	▲	
San Diego State University	▲	●
UC Los Angeles		●
UC San Diego		●
University of Southern California	▲	●



Industry Advisory Board

Mission:

To support MESA pre-college and university programs throughout California by: 1) providing industry perspective and advice to the MESA Statewide Office on policy issues, planning and funding; 2) serving as an advocate for MESA goals with policymakers in public schools, higher education, government and corporate sectors.

Major Activities for 1987–88:

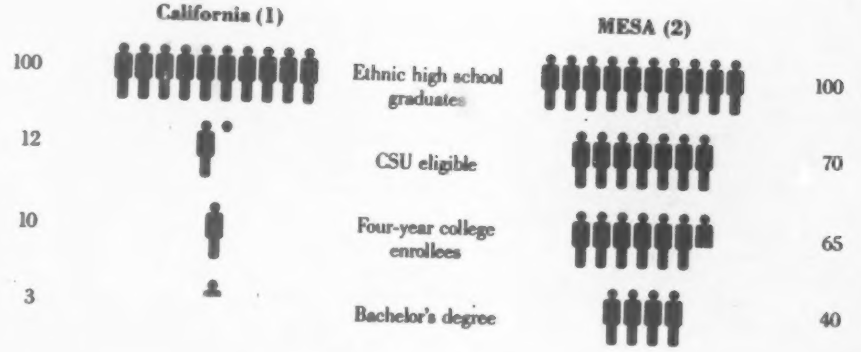
- Provided corporate perspective and input on MESA plan for regionalized management of program statewide.
- Further developed and strengthened industry support for MESA at the corporate vice-president level.
- Supported development of MESA Statewide Office outreach efforts such as the industry breakfasts, promotional video and industry brochure.
- Participated in initiation and implementation of a statewide conference for MESA Advisors, held in August, 1988.

Members

Aerospace Corporation
ARCO
Bechtel Power Corporation
Chevron U.S.A.
Exxon, U.S.A.
Fluor Daniel Corporation
General Dynamics
GTE California
Hewlett Packard Company
Hughes Aircraft Company
IBM Corporation
Litton Guidance & Control Systems
Northern Telecom
Northrop Corporation
Pacific Bell/Pacific Telesis
Pacific Gas & Electric Company
Ricoh Electronics
Rockwell International
San Diego Gas & Electric Company
Southern California Edison Company
Southern California Gas Company
TRW Inc.

The College Pipeline in California

MESA and Other California High School Graduates



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(1) California Postsecondary Education Commission college eligibility and college-going studies.

(2) Estimates based on data drawn from MESA enrollment information system.

MESA: Decade Of Progress

	FY78	FY79	FY80	FY81	FY82	FY83	FY84	FY85	FY86	FY87	FY88
High School											
Regional Centers	8	10	15	15	15	16	16	16	16	17	17
High Schools	23	44	77	93	102	115	140	142	134	127	135
Student Participants	819	1,442	2,092	2,104	2,519	3,096	3,820	3,962	4,176	3,108	3,409
MESA Graduating Seniors	113	272	413	664	785	890	1,204	1,122	815	778	850
Expenses	$144,490	$317,562	$545,823	$776,836	$821,009	$958,304	$1,036,250	$1,160,030	$1,252,150	$957,180	$1,014,272
Cost Per Student	**$176**	**$220**	**$261**	**$369**	**$326**	**$310**	**$271**	**$293**	**$300**	**$308**	**$298**
University: Minority Engineering Program (started in FY83)											
Colleges						14	15	15	15	16	17
Student Participants						1,115	2,143	2,393	2,644	2,488	3,006
MEP Graduates						0	201	195	117	209	351
Expenses						$285,000	$523,000	$626,254	$638,101	$635,181	$763,000
Cost Per Student						**$256**	**$244**	**$262**	**$241**	**$255**	**$254**
Junior High School (started in FY85)											
Junior High Schools								19	28	40	45
Student Participants								550	1,008	1,036	1,366
Expenses								$77,504	$125,920	$243,082	$366,841
Cost Per Student								**$141**	**$125**	**$234**	**$268**
Statewide Office Staff	2	3	3	3	6	8	11	12	12	10	11
Expenses	$118,119	$163,888	$188,512	$253,314	$292,136	$532,617	$598,701	$658,073	$741,808	$680,705	$736,173
Cost Per Student	**$144**	**$114**	**$90**	**$120**	**$116**	**$126**	**$100**	**$95**	**$95**	**$102**	**$95**
Total Expenses:	$262,609	$481,450	$734,335	$1,030,150	$1,113,145	$1,850,921	$2,261,007	$2,608,331	$2,757,979	$2,516,148	$2,880,286
Programwide Expense Per Student	**$321**	**$334**	**$351**	**$490**	**$442**	**$440**	**$379**	**$378**	**$352**	**$379**	**$370**

MESA
Mathematics,
Engineering,
Science
Achievement

Wilfred O. Easter, Director

Wilfred O. "Fred" Easter has served as Statewide Director of the MESA Program since June, 1986. Prior to assuming this position, he was a program manager for Control Data Corporation, directing the firm's computer-based education center for the Southeastern United States. Before joining Control Data in 1979, Mr. Easter held several positions at Carleton College in Northfield, MN, including Director of Minority Affairs and Associate Dean of Students. He did his undergraduate work in history at Harvard College, and graduate work in educational psychology at the University of Minnesota. He graduated in 1959 from The Gunnery School in Washington, CT, where he was the first Black student in the school's history.

Lawrence Hall of Science
University of California
Berkeley, Ca. 94720
415/642-5064

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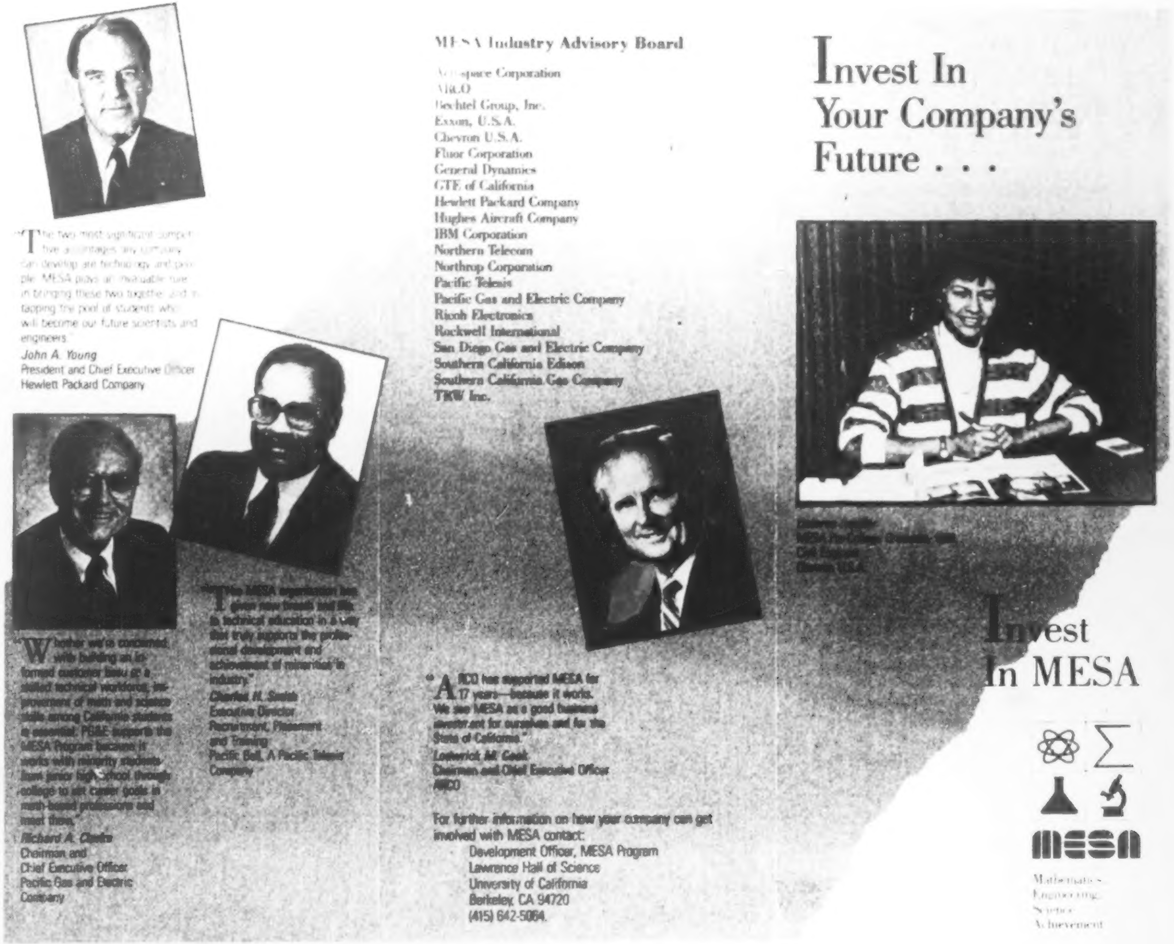

"The two most significant competitive advantages any company can develop are technology and people. MESA plays an invaluable role in bringing these two together and in tapping the pool of students who will become our future scientists and engineers."

John A. Young
President and Chief Executive Officer
Hewlett Packard Company

"Whether we're concerned with building an informed customer base or a skilled technical workforce, improvement of math and science skills among California students is essential. PG&E supports the MESA Program because it works with minority students from junior high school through college to set career goals in math-based professions and meet them."

Richard A. Clarke
Chairman and
Chief Executive Officer
Pacific Gas and Electric
Company

"The MESA organization has given new breath and life to technical education in a way that truly supports the professional development and achievement of minorities in industry."

Charles H. Smith
Executive Director
Recruitment, Placement
and Training
Pacific Bell, A Pacific Telesis
Company

MESA Industry Advisory Board

Aerospace Corporation
ARCO
Bechtel Group, Inc.
Exxon, U.S.A.
Chevron U.S.A.
Fluor Corporation
General Dynamics
GTE of California
Hewlett Packard Company
Hughes Aircraft Company
IBM Corporation
Northern Telecom
Northrop Corporation
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Pacific Gas and Electric Company
Ricoh Electronics
Rockwell International
San Diego Gas and Electric Company
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[illegible]

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MESA

Mathematics
Engineering
Science
Achievement

The Challenge

- **Meet Global Competition**
  Today, the United States is the world's leading debtor nation. The State of California conducts 66% of its trade with the Pacific Rim countries, with whom it carries a large and growing trade deficit.
- **Boost Engineering Enrollments**
  Our country's future economic competitiveness will be built on a foundation of well trained, highly motivated scientific and technical workers. But science and engineering enrollments at the college level have declined steadily since 1982, and California will soon face a shrinking pool of engineering graduates.
- **Build Excellence From Diversity**
  California is a demographically rich state, where ethnic minority groups will comprise a collective majority of the school population by the year 2000. Students from MESA's target groups are grossly underrepresented in science and technical majors. And the problem begins earlier, at the high school level, where nearly 60% of these students drop out before graduation.

MESA Works

MESA (Mathematics, Engineering, Science Achievement) provides a continuum of academic support services to underrepresented minority students from seventh grade through graduation from college. Since its inception in 1970, MESA's success has been built on a close cooperative relationship between industry and education.

- **Fully 80% of MESA high school students enroll in a four-year college the fall after they graduate; and the majority major in math-based fields such as engineering and computer science.**
- Engineering and computer science majors in MESA's Minority Engineering Program (MEP) persist in their studies at a rate that equals or exceeds all other ethnic groups. MESA alumni are employed by leading corporations around the state.
- MESA programs are administered through colleges of engineering on 22 California campuses, insuring a solid academic footing for students at all levels. Local industry advisory boards support MESA program planning and activities.

"I have always enjoyed studying math and science, but my participation in the MESA Program turned that interest into a career goal in engineering. Now, I'm directly involved in the design and development of the space shuttle main engine."

Lorrie A. Davis
MESA Pre-College Graduate, 1979
Structural Engineer
Rockwell International

"The Minority Engineering Program taught me the meaning of 'professional development.' Through summer jobs in industry, I've gained confidence to pursue graduate studies and a position in industry."

Robert Hilaire
MESA Minority Engineering Program Graduate, [illegible]
Graduate Student
Mechanical Engineering

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- Early identification and recruitment
- Structured study groups
- Academic enrichment during weekends and summer
- Career exploration
- Professional development
- Parent involvement
- Incentive awards
- Scholarships and summer employment

MESA Campus Centers

Pre-College Program ▲
University Program ●

North		
California State University (CSU), Chico		●
CSU Sacramento	▲	●
San Francisco State University	▲	●
San Jose State University	▲	●
Stanford University	▲	
University of California (UC), Berkeley	▲	●
UC Davis		●
Central		
CSU, Bakersfield	▲	
Cal Poly San Luis Obispo		●
CSU Fresno	▲	●
UC Santa Barbara	▲	●
South		
Cal Poly Pomona		●
CSU Fullerton	▲	●
CSU Long Beach	▲	●
CSU Los Angeles	▲	●
CSU Northridge	▲	●
Harvey Mudd College	▲	
Loyola Marymount University	▲	
San Diego State University	▲	●
UC Los Angeles		●
UC San Diego		●
University of Southern California	▲	●

Mr. **Walgren.** Thank you very much, Mr. Easter. That's a strong program, and we appreciate that testimony.

Let's turn to Mr. Pysnik at this point. I'm a little out of order in the way I went through it at the start, but there's a reason in here someplace.

Mr. **Pysnik.** Thank you very much. It's certainly a pleasure to be here—certainly from a small community of—city in New York of about 5,000 people, probably counting cats and dogs too; a high school of about 500 students. It's been interesting, the ripple effect that your request for our testimony has produced. It has increased the pride of the community, the excitement of the community to unexcelled levels. I've never seen it as excited as it is today.

I also want to thank some organizations that helped Kerri and I get here, and I probably should mention Joe, too. Ithaca College has funded all of Kerri's expenses to get down here. Kerri will be a freshman at Ithaca College this coming fall. The Catskill Regional Teachers Center, which is an educational organization in New York State, has provided funding to help pay for my flight down. And our school district, a very small one—a school district, in a time when budgets are being voted down left and right, told me, "Regardless of what happens to the budget, we'll get you there. Don't worry about that." And I am very proud of that.

I also would have to say that I'm very proud of the two people who are here with me today. They represent truly what the best of the young people in the United States mean, and I think you'll see that and hear that from their testimony.

Realize too that, being a classroom teacher, I much prefer dialogue. I love to be able to talk back and forth. To lecture puts me to sleep, and my students. So, hopefully, I'll be as clear and concise as possible, so that we can chat back and forth.

My testimony here will center around an examination of my written testimony in that I want to make some specific points, and those points being these. You saw in the initial testimony that I talked about the glamour of other professions. So then how does one approach the difficulty of bringing glamour and enthusiasm to science? We certainly change the media's look at who we are today. At least not quickly and easily. How then can we induce young people into science? I believe it is by helping them develop methodologies for developing an identity as a scientist. Not just that who are those scientists, and what do they do, but, I am a scientist.

I listened to the testimony earlier about that's—interesting science has to start early, and I couldn't more wholeheartedly agree. Yet we know that as the student gets up in the middle and high school the number of questions that they ask decrease incredibly when in a classroom. We need other settings, other than the formal classroom setting, whereby they now no longer answer with anticipated questions but are involved in actually developing questions and forming a science of their own.

Now, what I am saying, then, is that those young individuals who do want to be successful, who do want to have an identity developed, can be successful if working under conditions whereby they can show other people that they are a part of the scientific endeavor. They are actually people who are becoming scientists. They are actually scientists, and how—when involved in research programs. And the research programs at the different levels that I'll discuss in just a moment, allows all students, not just select students, to be a part of that. I truly believe that we cannot simply examine by specific tests, whatever, those students who should be funneled in, because many times we'll miss the students who don't show the potential early in life, who become the very best at a latter point in their life.

So, there are then some methodologies that we have found are very successful. One you've asked me to talk about, and that was summer science programs. You can see by our testimony that, although we're a small school, we've had students attend science institutes all over the United States. And because of that we feel that we have a lot of information to provide in terms of the success of those programs and the validity of what works best.

We believe, then, that among the very best—and I think Kerri and Joe will provide information for that—the very best of those institutes are those institutes where students are immersed in a research program. That is, the students is not necessarily taking a lot of structured programs that certainly they need for academic credibility, but they are working in true research endeavors, and hence, are scientists. They don't have to worry about when do I become a scientist. They're a scientist now.

I think that of all those programs one of the most successful is at Ithaca. It gives the students year after year hands-on experience. It gives the students chances to make mistakes. They've got to understand that science is not something that's already known; that you're tested on and if you know that you're a great scientist. We don't believe that. We believe that our students must know that they're developing the science of their day.

Now, you see what happens, then they take on an ownership of what they're doing. They take on responsibility. That's their project. And then talk about, is that person going to continue? You bet. They've become that scientist.

Now, the program at Ithaca College, we're very happy to say a number of Sidney students have attended. But the other interesting aspect of that research program is that typically there are many other students from even other countries, whereby, our students have been able to interact internationally with students from Holland, Germany, France, and so on. What better way for scientists to learn to be true scientists? Because that spirit of research is not done in a competitive manner.

Our world is full of competition, isn't it? Our schools, we compete in practically everything—sports, clubs, academics, our SATS. I seriously question whether science needs to fit into the role of a competitive endeavor, but rather, in my opinion, an endeavor which is collaborative, one in which we as a Nation as well as all other nations will produce a world that's fit to live in. Competition in science, we believe at Sidney, makes more mistakes than good effects. Hence, I can't overemphasize that.

The second important influence that we have seen in our students are programs whereby students can get involved in doing research at the local school like grant funding. This is a time when school budgets aren't all that great. To give you an idea, when I started at Sidney my budget for chemistry, which amounted to between 60 to 80 students, was $800. Today, it's about $1200. One cannot possibly run a research program, as you have seen in our testimony, by local funds. And certainly, local taxpayers couldn't expect to be able to support such a program. Therefore, outside sources are desperately needed and I believe encouraged to develop.

I again want to emphasize, though, we can easily fall into the trap of suggesting—let's see if we can build up, perhaps, the number of science fairs. They're good. They've done a lot. But what have we done? In many instances, we have provided a situation, a scenario where the student, if that student doesn't take home a ribbon, feels defeated. They've lost. Sidney beat Green. Green whipped Harpersville. I don't think that happens. I believe that science is a truly human endeavor where people aren't beating one another, or there's no box score.

As you can see from some of the information that Mary Jean Frank from NYSERDA provided, students in such research programs as theirs—and theirs is a competition, by the way. There are bonds that are given to the top students and so on. But for the most part it is a chance for those young men and women to get together to see what they've done, to get ideas, to say, "I know what I want to do next year."

You might have noticed in the testimony—did you see what was the most important thing to those kids? The most important thing was a sense of accomplishment that they developed. It wasn't the fact that they necessarily said, "I'm going to go on to college," "I'm going to be a scientist," but, "I've accomplished something," "I'm a scientist and I'm proud of it." I'm proud of them too.

I also reflected, just briefly, on the fact that I think you realize it is quite clear that industry as well as colleges do provide equipment whereby students can do research at local schools. I suggested that that be encouraged. Let me offer some cautions, though. I see so much equipment being donated to various schools, and never used. I truly believe that if programs are to be implemented and encouraged that rationale be developed by the receiving school, an examination of what have you done—not necessarily one, two, three, four, this is what you must do, but what have you done with this? Not just—Is it still in the closet?

I'd also like to rationalize why I mentioned one corporation and not another. You may have thought that's a bit unfair in terms of those who have provided materials for us. And probably the best reason that I want to mention Perkin-Elmer Corporation in terms of their support actually came to me again, in terms of emphasizing this, while Kerri and I were on a small commuter flight, bumping over Pennsylvania, to get here. I was reading the '89 issue of Piedmont to try to display to Kerri courage; that while I'm reading, obviously I'm not frightened. In that issue that I read, while going up and down a thousand feet at a time, I discovered a program that evidently is working in Seattle called PIPE—Partners in Public Education—in which businesses are actively involved in teaching in the schools and working with those school districts. And one of the comments that was made was, that they were very proud of the program because once the company started their work they didn't disappear, they continued their assistance. And I mention specifically Perkin-Elmer because they have dedicated their interest in us and have not said, "Here's a piece of equipment, put it in your lab. And now put us in the newspapers. Goodbye." They have supported us year after year, and hence I mention them.

That last approach, then, that I mention in terms of developing the research concept and scientists themselves, is whereby, regardless of what one has, certainly I would encourage the development of research types of programs both formal so that academic standards can be met, and informal. You see what this does? For formal, then, perhaps, we can be selective if we wish. But informal still gives that student who is still lagging behind, that chance. Do they have to be seniors? No. Take a ninth grader. They'll be off-the-wall, perhaps. They might be fidgety. They might not know much chemistry. But you can see then, that the longer they have in terms of being exposed to that science, the better off they'll be. And then, obviously, that means that if you take all of the three tactics that I suggested, put them together you've got a scientist. There are two scientists here.

Finally, then, some more caution. And that caution is that in order to be a scientist you must be hands-on. You can't be skeptical about getting your hands dirty. Therefore, in the development of science programs, I really want to suggest that it's important that we be very, very cautious about what we use to teach science. I want to urge that concerns over how much do we simulate and how much do we do should be really looked at closely. If my students couldn't touch and use things, then I'm not sure how excited they'd be about becoming scientists.

Finally, then, I'd like to speak very briefly about my comment, that you might have thought was rather strange, about a chemist by profession and a teacher by insanity. That was by no means a derogatory statement toward teaching. But, you see, it is important that we have new teachers understand that they are not just to impart information. They, too, must be, as science teachers, scientists themselves. They must feel like a scientist. Yet, as I look at the training programs of science teachers, I find rarely do they have any research experience. Rarely. Now how can they develop scientists? They can teach chemistry, biology. But can they tell the student what it's like to make it, to do something that's worthwhile in the lab? I don't know. I don't know.

Finally, this is a request. If I should leave today and not hear from the committee, and not be able to continue a dialogue with you, with some of you, I would be saddened that I've not been able to suggest our excitement about wanting to continue our involvement in developing true, good programs in the United States—programs in science that we can be proud of. And I would ask that I be able to continue that conversation with you in the future.

We, too, at Sidney, are very enthusiastic about saying to you we would love to have you come up and visit us.

Thank you very much.

[The prepared statement of Mr. Pysnik follows:]

THE BIRTH AND GROWTH OF A SCIENTIST - ALTERNATIVES FOR EXCELLENCE

Testimony provided for the Committee on Science, Space, and technology, U.S. House of Representatives, Washington, DC on June 7th 1989.

Submitted by:

Mr. David Pysnik
Chemistry/Research Instructor
Sidney High School
95 West Main Street
Sidney, New York 13838

The funneling of students into the science and engineering "pipeline" today is indeed sometimes a rather difficult task. Young students are confronted with a multitude of alternatives of vocations and lifestyles which in many instances are much more glamorous and lucrative than science. The media paints individuals such as sports figures, business men and women, actors, and singers as those people who "have everything". Not only are their talents applauded but their human characteristics, both good and bad are examined in what seems to be a day-by-day barrage of pictures and words. The scientist, on the other hand, tends to be examined by the public only when a major breakthrough occurs or if scientific work sparks a moral or ethical issue. In many instances then, the scientist or engineer appears to be really interested in only the project at hand or the implications of his or her own work. Their life as a whole and their other non-scientific talents may never be considered. Often the public may view scientists, therefore, as "oddballs" who must be extremely brilliant, live mostly in their laboratory, and have little to offer outside their realm of expertise. This testimony will attempt to suggest methods by which individuals can become interested and active as scientists and engineers, as well as concerned and active citizens of our great country. I offer these recommendations not just because the research program at Sidney has been recognized at the state and national level as one of the best in the United States but also because average young men and women from a small rural school in upstate New York are deciding to become scientists and, in fact, accomplishing just that. Realize, that though some statistics will be provided to help support various arguments, one must recognize that those statistics are from a rather small sample of students. Hence, caution must be used in their interpretation.

One of the most influential activities that helps to promote student interest in science before entering college is the summer science institute. Over the last decade and a half over one hundred and forty Sidney High School students have attended science programs at the following institutions: Ithaca College, Brookhaven National Laboratory, Alfred University, Hartwick College, Oregon Museum of Science and Industry, Case Western

Reserve, Clarkson University, Depauw University, Northern Montana College, Michigan Technological University, University of Wisconsin, Carson-Newman College, Heidelberg College, United States Naval Academy, Rochester Institute of Technology, University of Wyoming, and Roswell Park Cancer Research Center. Some of these outstanding institutions have offered programs which were funded by the National Science Foundation. We at Sidney are very proud of the fact that this number of students represents more participation in such programs than practically the entire participation by students in the New York Southern-Tier school districts combined. Of those Sidney High School students who majored in science or engineering in college, over sixty percent attended a summer science program, usually in their junior year. These students represented about eight percent of the student class population. One might note too, that of those students attending the summer institutes about thirty-six percent were women. The program offered in the chemistry department at Ithaca College is one of the most innovative and productive for our students. Due to funding provided by the Research Directorate of the National Science Foundation, Division of Chemistry, Chemical Dynamics Section, and the encouragement and support of Dr. Kenneth G. Hancock who is Deputy Division Director, research positions are available in the chemistry department at Ithaca for a high school instructor and three or four students. Over ninety percent of the students in this particular program went on to choose a career in the sciences. When interviewed, students consistently suggested that their summer experience was decidedly influential in choosing a science or engineering career. Students also suggested that the programs, which emphasized research activities as opposed to highly structured programs, were superior in terms of developing confidence and enthusiasm for their future scientific work. Two students, Miss Kerri Shea and Mr. Joseph Suriano, from Sidney High School, testifying at these hearings will discuss among other topics the importance of research oriented institutes. As a result I cannot emphasize enough, the importance of continuing the funding for such programs and, if possible, providing seed monies for additional programs at even the secondary school level where an outstanding program could be made available to more students than those who normally attend that school.

A second important influence on student's decisions to go into the science field is research programs sponsored by state and private industry which can be pursued in the home school environment. Since 1982 about twenty-five Sidney High School chemistry students have written fourteen different research proposals. Twelve have been funded by the New York State Energy and Research Development Authority, one by New York State Electric and Gas Corporation and one by the Catskill Regional Teacher Center, Oneonta, New York. These proposals have each received grant monies of $500 to $1000, allowing students to purchase materials for use in their research. Again, I would suggest that this is quite exceptional for a small school such as ours when one considers that we are sometimes competing against what historically has been the best science schools in the state. The New York State Energy and Research Development Authority (NYSERDA) Program, which has grown to be one of the more prestigious science research competitions in the United States, has been functioning since 1982. Mary Jean Frank, Assistant Director of Communications for NYSERDA, has compiled some statistics which suggests considerable success in terms of encouraging students to enter the science "pipeline". In her speech at the Symposium on Research in the High School Environment at the American Chemical Society's 194th National Meeting in New Orleans, Ms. Frank suggests that surveys of the students participating in the research competition are very encouraging. The report states that eighty-three percent of the students in the competition felt that the experience had from some, to strong effects on encouraging them to learn more about energy research and development. Forty-four percent of the students reported that their participation in the student competition had at least some effect on their choice of college course and/or career goals. Twenty percent of those majoring in engineering said the competition had a strong effect on their choice of college and/or career goals. The most rewarding aspect of the competition, according to the students, was a sense of accomplishment. Fifty-two percent stated that the chance to have their work recognized was of greatest significance. Realize too, that informally both college and industry is making an impact on the research programs in schools by the donation of used equipment which, for the particular company or college, is technologically outdated but is of tremendous value to the secondary school. I'm proud to report that in the last fifteen years I have received over 1.2 million dollars worth of equipment from colleges, universities, and companies such as Perkin-Elmer Corporation, for use in our chemistry laboratory. My recommendation would certainly be for the continued support of such programs and additional funds allocated for the encouragement of even more. In addition, incentives should be provided for the continued assistance which organizations give to schools in terms of project support as well as donations of high technology equipment.

The third and equally important consideration for the development of scientifically competent and literate individuals is the science research program at the home school. At Sidney High School, students in grades nine through twelve of varying abilities are encouraged to develop or be a part of a research project. In chemistry there are typically ten to fifteen students involved in perhaps three or four investigations. Note that not all of these students have taken or are taking chemistry and that they are not necessarily the most outstanding students academically. If the student can begin a project and continue that work for perhaps two or three more years, then he or she will develop a true pride in the work and potentially an interest in becoming a scientist. Often this gives the student who might never think of a scientific career or might never be identified as being scientifically talented, an opportunity to really find out "what is inside". In many instances the students spend so much time on the project that it is written up in the form of a course so that the student receives academic credit. Students at Sidney also have the opportunity to take a formal research course their senior year in which they examine many high technology methods of analyzing the world around them. Instrumentation typically used in the research course includes visible and ultraviolet spectrophotometers, infrared spectrophotometers, atomic absorption spectrophotometers, gas chromatographs, bomb calorimeters, differential scanning calorimeters, and interfaced microcomputer systems. Although there is limited information at present, it seems that the approach of encouraging many students to participate in scientific endeavors at the high school level is rather successful in terms of improving scientific literacy. Encouraging individual research as opposed to providing various levels of structured courses for students seems to provide a greater degree of enthusiasm toward science and therefore an increase in the number of students who even consider a science or engineering career. Historically, I have found it most difficult to obtain direct federal funding for such curriculum development and equipment purchases in the last fifteen years. Our last proposal to the Department of Education's Teachers as Researchers

Program titled "Instruction Through Research" was not funded and in the rejection letter we discovered that out of one hundred and sixty four applications only seven were funded for the fiscal year 1988. Those seven awards totaled only about $35,000 all together. I therefore strongly recommend that funding for such programs be elevated dramatically in the future and a program be implemented to promote such funding.

Certainly the issue is a complex one. This testimony has not even touched upon a very serious consideration - that of the teacher and his or her role in the whole process. A multitude of training programs will have to be considered and reconsidered. Young teachers of science must realize that they cannot simply think that imparting knowledge is their only job. They must realize that the methods they learn at college are only a beginning and that the attention of young people must be captured by using and developing the incredible technology which they have at hand. Traditional classroom settings will not necessarily "lure" the young person to science, especially if that individual is not the outstanding science "whiz" of yesterday. Salaries and working environments make the problems at hand interspersed in a social network which evokes more questions than solutions. I sometimes joke with my students who are considering teaching science as a career, that "I am a chemist by profession and a teacher by insanity". What I am trying to suggest to them is that undoubtedly the career can be difficult at times due to comparatively low teaching salaries, inadequate facilities and stressful working conditions. However, my choice of vocation, which might not seem sane to those who want the "everything in life", is a choice which necessitates wanting to make a difference. That difference comes when I can show a young woman or man the value that science truly has in our life. Should the student discover that value first-hand then, very possibly, a scientist has been born.

Biographical Sketch

David Pysnik
Sidney High School
Sidney, New York

David Pysnik is a chemistry, research, and data processing instructor at Sidney High School, Sidney, New York, in addition to chairperson of computer education for the school district. He is an adjunct instructor for State University of New York at Delhi in data processing, a chemistry instructor for The Hospital in Sidney, NY in the nursing program, and a research associate in Chemistry at Ithaca College during the summer. He has authored papers in education as well as chemistry and has presented numerous papers at the local, state, and national level especially research programs in high school. His students have won awards in science contests sponsored by such organizations as The American Chemical Society and Sigma Xi. Since 1982 he and his students have had twelve grant proposals in chemistry funded by The New York State Energy Research and Development Authority, three proposals funded by the Catskill Regional Teacher Center and one proposal funded by New York State Electric and Gas Corporation. Currently, in addition to his research work, he is involved in developing and presenting materials which demonstrate computer interfacing applications to middle and high school teachers as part of a National Science Foundation program at Ithaca College funded over a four year period.

Mr. Walgren. I thank you very much, Mr. Pysnik. We appreciate that enthusiasm.

Where's Sher's district in all this? Right in there, huh? Well, you know Mr. Boehlert, of course?

Mr. Pysnik. I certainly do.

Mr. Walgren. He has an abiding interest in this area, and I know he won't lose touch with you. But we also don't intend to lose touch on our own, as a committee as a whole.

Mr. Walgren. Let me ask Ms. Shea, and then Mr Suriano. Obviously, all of us up here didn't do what we hope you will do. We didn't become scientists in any way, shape or form, and here we are wishing that others would follow that. And we look to you, and we see that interest and track, and we're curious about what you see as the encouragements to pursue science, why do people do it, how can we get more people like yourselves interested in it, and what kind of message would you like to put in the national hearing record at this point.

Mr. Roe. Would the gentleman yield?

Mr. Walgren. Be happy to yield to the chairman of the full committee, Mr. Roe, from New Jersey.

Mr. Roe. I think what the gentleman from Pennsylvania is trying to express to the two young—the young lady and gentleman we have with us is that he doesn't want you to become politicians, he wants you to become scientists.

[Laughter.]

Mr. Roe. There might be something self-serving there. I'm not quite sure about that.

Mr. Suriano. Members of the committee—

Mr. Roe. Mr. Suriano?

Mr. Suriano. Thank you. And invited guests, my name is Joseph Suriano. Presently I'm working as a summer student at DuPont Central Research and Development Experimental Station in Wilmington, Delaware. Prior to going to DuPont, I received a master's degree in chemistry from Bucknell University and a bachelor's of science degree from Ithaca College. This fall, I plan to attend the University of Minnesota, where I'll begin working toward a Ph.D. in chemistry.

During my graduate and undergraduate years, I've been involved in a number of research programs, both during the school year and in the summers. One such program gave me the opportunity to do research at the University of Leiden in the Netherlands. The experience of doing research and interacting with students and professors from another country is one I'll always remember.

I first became interested in chemistry after attending a structured chemistry summer program at Ithaca College. Although this program was not research oriented, it was very educational and practical. The program did two important things for me: one, it allowed me experience in chemistry firsthand; and, secondly, it permitted a great deal of one-on-one interactions with professors, talking about their research ideas and other aspects of chemistry. I believe it was seeing the enthusiasm and excitement, not only in these professors at Ithaca College, but also in the classroom with Mr. Pysnik, that led me into the field of chemistry.

The value of summer programs which provide opportunities to high school students to do research at colleges and universities is enormous. I feel it is necessary, however, to emphasize research-oriented programs, for they enhance the learning experience for the student. In a summer research program, a student not only becomes acquainted with a laboratory where he or she will learn some of the basic techniques and skills of synthesis, become familiar with common instrumentation, and be introduced to some theory, but the student also is able to interact directly with a professor, where they will discuss research ideas and ways to expand a particular project.

Furthermore, at a college or university the student has ample time and the resources to investigate or experiment with other areas of interest. With research-oriented summer programs, we are encouraging students to use their mind, imagination, and their creativity, while introducing them to the most exciting aspect of the field. The fun and excitement of chemistry begins with research, therefore it makes sense to give high school students the opportunity to experience this excitement as they begin to choose a career.

These types of creative programs are what we as a country need more of at this time. Giving students the opportunity at a relatively young age to experiment and explore these areas is extremely rewarding. Students that are given this opportunity find themselves more relaxed and comfortable in the college environment, so as their knowledge of chemistry increases, their thought process is less inhibited. They are more willing to ask questions, offer ideas, and suggest explanations.

By the time students reach college-level chemistry, they should not be hindered by having to become familiar with basic skills and instrumentation. They should be able to use their minds and their previous background to reach higher levels. I believe it is through giving students the opportunity to be involved in research programs that progress will be made, and better and more creative scientists will be coming out of colleges and universities.

I'd like to thank you for your attention and for taking the time to listen to my views and those of the other guests. With effort and relatively little financial support, programs like these can and will make a considerable difference in our scientists.

Mr. WALGREN. Well, thank you very much, Mr. Suriano. Appreciate that.

Ms. Shea, would you like to give us a guide here and ground on which we're embarked.

Ms. SHEA. Okay. I participated in a rewarding educational research program at Ithaca College last summer for six weeks. Dr. Hines Cope, who is a professor at Ithaca, was the director of the program, which totaled 19 students. There were four from Sidney High School; two from the University of Leiden, the Netherlands; two from the University of Durham, in England; two from Morehouse; one from Spellman; and eight from Ithaca College.

The focus of the work involved the synthesis of a styrene from its related ketone. There are a number of different steps involved, going from the ketone to the styrene. Once a final product was obtained kinetic studies were done, and kinetic data provided information concerning the proton transfer mechanisms of organic molecules. Of the six weeks that I spent at Ithaca, about four were spent on synthesis and two were spent on the kinetics work.

From the whole experience, I feel that I gained much knowledge and understanding of the world of scientific research; in organic chemistry, more specifically. It was a unique addition to be working with four foreign students, and I feel that my learning extended beyond the lab. The atmosphere at Ithaca led to a high quality of learning at a relaxed level. The type of work was primarily individual, but we all did the same type, so we were able to get help from other students.

The group was also at different levels. I was working with college juniors and seniors, while I was still a junior in high school, so I was able to get help from other students instead of always going to Dr. Cope with a problem.

I feel that I gained much from the research work at Ithaca because it was not a structured course as I have had in high school and will have in college. The level of learning was higher than a comparable structured college lab course would most likely be.

I was invited to attend the Ithaca College research program by David Pysnik, who is my high school chemistry teacher. I was one of three juniors, and the only female, asked to attend. From my experience, I decided to pursue a career in chemistry. Before Ithaca, I had careers in the field of secondary education or social services. I believe that Mr. Pysnik saw possibilities within me that I didn't realize existed. Without my Ithaca College experience last summer, I doubt that I would be attending Ithaca in the fall to major in chemistry.

My future career goals have always been to attend a 4-year accredited college or university to obtain my bachelor's and then my master's degrees. This hasn't changed any, but rather expanded. I will be attending, as I said, Ithaca in the fall to do my undergraduate studies and to continue doing research. I will then go on to graduate education to acquire my master's of science and eventually my Ph.D. I don't know at this point what kind of job I would like to hold because the field is so open, but I have many areas from which to choose. I do plan, however, on doing research because I've been involved with research as long as I've been involved with chemistry and it is very exciting. And I've considered teaching at the collegiate level, but nothing is definite.

I'm grateful to Mr. Pysnik and to Ithaca for the opportunity to do research and to learn what chemistry research entails, and for supporting me throughout my senior year as I've made decisions about college and a field of study. I feel that I've grown in many ways from spending my summer at Ithaca last year and from doing the research. I'll use what I've learned throughout my life in more than just my career as a chemist.

I feel that the research program was highly beneficial and an experience, that if possible, everyone should encounter.

Thank you.

Mr. **Walgren**. Well, thank you both very much. We appreciate that, and we'll look forward to coming back and seeing what else we might be able to draw out from your experiences.

Let's then turn to Dr. Layman.

Dr. **Layman**. Chairman Roe and Mr. Walgren, I again thank you for the chance to appear before this committee and to describe two of the NSF programs that I've been associated with. We'll shift gears a little bit and talk about teachers primarily. And the two projects are the University of Maryland Middle School Probeware Project, and the other is the American Association of Physics Teachers' Physics Teaching Resource Agents program.

The Probeware Project is an example of the use of technology and it has two uses as defined by our project. It is of great value to the teachers in a way that I will mention in a moment, and great value to the students in much the same way. To describe what Probeware is, since technology is obviously playing a role in our discussion today, an example would be having a computer with two temperature probes attached to the computer and an ability to graph the temperature of physical systems over time so the computer will manage to transform information that might have been acquired manually into a dynamic graph whose character changes as the experiment progresses.

An example of the kind of experiment students do would be something called Isn't It Gradient, and this is really an outgrowth of something that our teachers worked out. If you have a large chamber of water and two temperature probes, one placed near the top surface and one placed near the bottom surface, and ask students to then immerse an ice cube and hold the ice cube at the bottom of the chamber with a pen or a pencil or something, they get a graph of temperature versus time and realize that the temperature at the bottom of the chamber immediately drops and continues to drop, of course, as the phase change occurs for the ice cube and it cools, but that the temperature at the top of the chamber remains quite constant.

So they have physical evidence of the behavior of a physical system, and when they interact with their lab partner, and, hopefully, just two at a computer, the information that they are discussing is dynamic. The moment they see the temperature of the lower portion change and the temperature of the other portion not changing, the upper portion, they begin to wonder what's going on because it's not something that they've ever been exposed to, and it's something that is giving them personal information about the behavior of the system.

And after a while they realize, especially if some of their lab partners have lost track of the ice cube and it rises to the top and the top of their solution gets a little bit cooler before they can get the ice cube back down, they have dynamic information about a system, and any discussion and questions that they ask and answers that they provide they get from their own personal observation. We are not telling them about science. We are not having static graphs presented in textbooks. It is actually a dynamic system.

Some of the students can then say, "Well, what if we had left the ice cube at the top?" And, of course, they can do that. And they'll discover that the top cools but the bottom also cools, and then they'll realize, if they make the analogy with air systems, that hot air rises and cold air falls. They've learned this from their physical sciences, and they'll begin to realize that their physical system for which they've gathered information is behaving in exactly the same fashion.

And an analogous experiment would be then to put a heating element at the top of the water, with again the two probes top and bottom, to put energy into the system, and recognize that under those circumstances the top of the water gets hot but the bottom of water does not get hot. In other words, they have a counter example of something where under those circumstances no convection occurs, just as it didn't occur when they held the ice cube at the bottom of the chamber.

My point is that students are, in fact, doing the kinds of hands-on activities, and the kind of information that you are asking them to make judgment on is information that they have personal access to. They don't have to turn to the teacher for the information. They don't have to go to the textbook for the information. The information is there and it is the basic for their judgments. And in our teaching and learning of science, and we emphasize the learning of science more than teaching, too often the students are totally dependent upon outside sources—the teacher, the textbook, the laboratory that is so designed so that it works perfectly, so that they can get the information from their neighbors and not worry about the fact that they didn't make personal observations. With MBL they must make the personal observations.

Let's come back to the teachers for a moment. We have a summer workshop of three weeks' duration in which teachers use the very same equipment to do a series of experiments, and one aspect of this project is that we evaluate the progress of both the teachers and the students. So we know from interviews with the teachers before the 3-week summer workshop what their understanding is of the ideas of temperature, which is the only thing we really measure, and then we infer heat energy—that we know something of their ideas of heat energy and temperature. And then we interview them at the end of the 3-week summer workshop to again assess their levels of understanding, and if MBL is really successful, it is as successful with the teachers in allowing them to change their concepts of heat and temperature, which we know are lacking when they come to us, just as it did for the students. And the workshop models the behavior, on the part of the teachers, that we would like them to honor when they begin working with their students back in the junior highs.

So the project really is a change of teacher concept in the first summer, getting used to the technology, the equipment attached to the computers; learning enough about it to be confident to go back and work with their students in middle school physical science; going back, working with those students for the year, ironing out some of the difficulties that we know will arise but can't be described in advance of their experience.

But then we have them back a second summer, and in the second summer we can then begin to fine tune some of the concepts that they didn't come in with firm attachment to at the beginning of the initial workshop. So that we can monitor and know that their concepts are changing, just as the students' concepts are changing. So we monitor both the students in terms of graphing skills, science process skills, knowledge about heat and temperature, but we also monitor the progress of the teachers.

So what I am describing is one kind of summer, follow-up summer program that I certainly recommend for support within the NSF process. We need to approach our high school and our junior high and elementary teachers with the opportunity to do science in this fashion; in fact, this is more closely akin to the kind of research science just previously described, than it is to the classic textbook/laboratory science that we are used to in the past. So that's a very important program. The long-term interaction is very important for the teachers because ultimately it has a very great effect on how they choose to have the students interact with this learning process.

The other program that I'll comment on briefly is the Physics Teaching Resource Agents program, which is sponsored by the American Association of Physics Teachers, again with NSF support, where we design three separate summer programs to prepare outstanding high school physics teachers to become resource agents. Meaning that their obligation after completion of the program was to return to their own school districts and their own geographical areas and offer workshops for fellow teachers. Their primary obligation was to offer two workshops a year, and the workshops could be some that were modeled and offered as part of the summer training program or they could be workshops that the teachers themselves generated because of their knowledge of the local needs.

One of our target audiences for the PTRA activities were the underprepared or crossover physics teachers. As you well know from the literature that we all have access to, the number of physics majors teaching high school physics is very small, and the number of those who have been trained in chemistry and other areas who do our physics teaching is quite large. They need the support of other physics teachers. One of the nicest outgrowths of this program is that, even though we design programs primarily for the secondary teachers, they have evolved programs for junior high teachers, lecture demonstrations, hands-on science with all the topics that you could ever dream of, and they've also come up with some very nice workshops for elementary science teachers.

And I think the secondary teachers who develop this skill can often deliver this kind of help to their colleagues at the middle school and elementary level, as well as the secondary level, in a way that some of us at the colleges and universities do not do as successfully. And, of course, in a multiplier effect, if we are going to reach a great many of our junior high and elementary teachers, although NSF is going to shift some of their emphasis into the elementary and more into the junior high level, we need to take advantage of well-prepared high school teachers trained for leadership roles, trained and willing to assume the responsibility for leadership roles to have the kind of amplifying effect that I think we deserve from our NSF money.

So, in effect, what I'm describing is the emergence of an individual who can be classified as a professional. And they are recognized professionals in this program because they have honorarium to be collected when they do a workshop—only $200 total. They had $500 available to cover the cost of doing workshops, although many have parlayed that into matching funds that far exceed the NSF commitment, and there is a comment about that in one of the footnotes of the written testimony. And they have, in fact, emerged as a group who have become very effective in representing the physics community in this enterprise.

Now the one factor that is going to be difficult to sustain, although we must try, is the chance for this group to meet from time to time to recharge their batteries. It's one thing to go out and do workshops and to accomplish a great many things in your own region. It's quite another thing then to have an opportunity to return as a group and compare notes, gain new ideas, and continue to sustain the mutual effort that it takes to do this kind of activity on top of your major teaching activities.

Years ago, we were very critical of high school teachers who appeared at two or three different summer workshops—they were called workshop groupies or something of the sort—and we tended to think that may not be appropriate use of NSF monies. The view that I have, and, in fact, it emerged more strongly at a recent NSF directors' meeting, is that we now have people who have attended a number of institutes and workshops—the Woodrow Wilson program, the prisons program in Iowa, the PTRA program—and, in effect, in each of these programs they have acquired a little higher stature as a professional; and what is implied in these programs that was quite different than our summer institute work a number of years ago is this obligation to go out and share their expertise with others in the community.

And I think as long as that remains a theme, and it is a theme now in more of the NSF programs, then we're going to get the kind of leverage for these programs that we need for the expenditures made. Let me give you just one example.

The Presidential Awards program had a recipient, who was a PTRA and who is from Minnesota, and had received his $5,000 stipend as part of the Presidential Awards program, returned to his State and worked very hard to be sure that that money was available to other teachers. So that it wasn't something that he used just for his own personal gain. He attended a State meeting and discovered that his superintendent had not made any application for the Title II money that the district was eligible to receive. He returned to his district very chagrined—that's not the phrase that he used—found out that the superintendent indeed had not made application, arranged to have it done, and parlayed his $5,000 into an additional $7,000 from his district, and with external money finally ended up with a funding level of roughly $20,000 that this high school physics teacher could then use to sponsor programs for other teachers. So there are many, many examples of where these professionals, that may start with us as colleagues and may exit as professionals, go out and do things that we wouldn't have predicted in advance, simply because they've now emerged as strong representatives of the teaching profession, in this case physics or physical science.

And I think the more we can do in any of our programs to support that kind of change in the individuals involved, the more successful our funding is going to be in equivalent programs.

Thank you.

[The prepared statement of Dr. Layman follows:]

Congressional Testimony

of

Dr. John W. Layman

Professor of Physics and Science Education
University of Maryland, College Park
College Park, MD 20742

for

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

Hearings on Science and Mathematics Education

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Collaborators

Dr. Joseph S Krajcik
Co-Principal Investigator, UMMPP Project
Science Teaching Center
University of Maryland
College Park, MD 20742

Dr. Jack M. Wilson
Co-Principal Investigator, AAPT PTRA Project
Executive Officer
American Association of Physics Teachers
Department of Physics and Astronomy
University of Maryland
College Park, MD 20742

Introduction

I am pleased to have been asked to provide descriptions of two National Science Foundation (NSF) sponsored programs that show promise of improving science and math education in the United States and to be given the privilege of making suggestions for the role that the the National Science Foundation should play in fostering such programs.

These two projects are quite different in that one is a national project sponsored by a professional organization, the American Association of Physics Teachers (AAPT) and the other a local project carried out by the Science Teaching Center at the University of Maryland with the collaboration of four school districts in the Washington D.C. metropolitan area.

Both projects involve improving the skills of practicing teachers. In one project teachers were chosen for their potential to become Physics Teaching Resource Agents (PTRA) obligated to work with other teachers in their local area to improve physics teaching at all levels. In the second project, teachers were chosen by their school districts to become the first to have their middle school students utilize microcomputers with sensors to carry out some of their laboratory investigations.

Both projects have evaluation components to assess their effectiveness. In the middle school project the evaluation is being carried out as part of the project by those providing the instruction and followup activities. In the national project an independent evaluator is looking at the impact of the program via an extensive survey of all participants. An accounting of the activities will also be provided by the program staff, but I choose to share the preliminary findings of the external evaluator at this time.

I will first describe the University of Maryland Middle School Probeware Project (UMMPP) and then the American Association of Physics Teachers' Physics Teaching Resource Agents program.

University of Maryland Middle School Probeware Project
Directors: John W. Layman and Joseph S. Krajcik
Science Teaching Center
University of Maryland, College Park, MD 20742

Objectives

The University of Maryland Middle School Probeware Project (UMMPP) is a combined implementation and research project with the following objectives: 1) to prepare middle school science teachers to help their students utilize microcomputer-based laboratories (MBL) in their science activities, 2) to strengthen the teachers' own concepts related to the MBL activities, 3) to enhance student understanding of some essential science concepts, 4) to develop science process and graphing skills of junior high students, and 5) to assist teachers in expanding, developing, and modifying curriculum materials that can be used in their classrooms. UMMPP is a cooperative venture between the University of Maryland Science Teaching Center, and four local school districts: Fairfax County, VA; Montgomery and Prince George's Counties, MD; and the District of Columbia. Advanced and introductory workshops to prepare teachers to use microcomputers as laboratory tools took place in the summer of 1988 and will again occur in the summer of 1989. Classroom use as well as monitoring teacher and student progress took place during the 1988 - 1989 school year and will again occur during 1989 -1990.

Procedures

In this project, teachers first attend a three week introductory summer workshop designed to prepare them to use microcomputers and the associated probeware with their students. They return to their classrooms to implement the program, receive classroom visits by project staff members, and attend district followup meetings. They then return to the university for an advanced workshop during the second summer. In this workshop many of the problems encountered during the academic year are addressed, new probes added, and further development of the teacher's own concepts may be made.

Research Objectives

The first research objective is an examination of the following question: What is the effectiveness of MBL in helping middle school science students learn graphing skills, science concepts and science process skills? A secondary question arises about the teachers themselves. The overall effectiveness of MBL may also depend upon the teachers' understanding of how to use the new technology, their personal knowledge of the concepts and skills, and their knowledge of how to enable the students to fully learn these concepts, skills, and processes. We have chosen to carefully examine both of these questions within this project.

Initial Year

The first year of operation of the three year project has prepared thirty teachers from three different counties to enable their middle school students to use microcomputer based laboratories (MBL) in some of their science laboratory work involving temperature and heat energy. These teachers averaged four classes with 26 students per class. We estimate that 3,000 students have used MBL during the 88-89 school year in a wide variety of school settings. We have monitored the students' progress, but have not completed analysis. All three counties involved in the project are integrating MBL into their middle school curriculum.

Teacher Findings

We have completed an analysis of data concerning the concept and teaching procedures knowledge of the teachers from the first summer's workshop. This data was gathered using a structured interview process. The analysis indicates that prior to the workshop, the middle school teachers held alternative concepts related to temperature and heat energy as well as weak ideas on how to teach the concepts. After the workshop, the teachers' ideas regarding temperature changed, but many teachers still held alternative concepts or had incomplete ideas regarding heat energy. The teachers did show progress on their knowledge of how to teach the concepts. These teachers will return for a second summer workshop which will allow them to return to these same concepts and issues having had one year of personal experiences with the materials and their own students using MBL.

Although the work accomplished to date has made some inroads in helping teachers to change their content knowledge and to understand how to teach the concepts, more work still needs to occur. We did not expect the teachers' concepts to change drastically, nor did we expect them to develop rich understanding of how to teach the concepts as a result of only a three week workshop. We strongly believe, and it is beginning to be supported by our early research work, that to help teachers form appropriate personal scientific concepts, develop a deep conceptual understanding of how to teach science concepts, and have their students use new technology in the science classroom requires careful work over a prolonged period. We will try to determine whether the model of two summer workshops and two academic support years is appropriate for introducing microcomputers as appropriate tools for students and teachers.

Minorities and Women

Teachers in this project have noted that the microcomputer based laboratories are especially effective with the average and below average students. It also seems to be a gender and race free device that allows each student to derive personally acquired information about the real world, something that they have not been able to do in the past. This is valuable in an area such as Washington D.C. where there are large numbers of students for whom English is not their native language.

PHYSICS TEACING RESOURCE AGENTS program
American Association of Physics Teachers

Directors:
John W. Layman, University of Maryland
Jack M. Wilson, American Association of Physics Teachers

I will provide an outline of the character of the AAPT PTRA program and concentrate on the independent evaluation phase of our work.

PTRA Outline

Goals
- To improve the teaching of physics at all levels
- To sustain in a professional manner a core of PTRAs

Three Cycles

1985	105 participants	Flagstaff, AZ
1986	100 participants	College Park, MD
1987	50 participants	Bozeman, MT
1988	50 participants	College Park, MD (1 day training)

Mechanisms
- Summer Workshops (Except 50 88s)
    - Formal training as PTRA
    - Introduction to workshops
    - Training in presenting workshops
    - Initial regional planning
    - Cutting Edge Physics talks

Attend National Meetings (full support 1st summer, partial all other)
- 85s access to 9 meetings
- 86s access to 7 meetings
- 87s access to 5 meetings
- 88s access to 4 meetings

Support Levels
- Travel and subsistence - national meetings
- Honoraria for presenting workshops ($100/100)
- Materials and Supplies support ($500)
- Special Projects Funds
- Equipment loans from AAPT
- Collegial support of members of PTRA

Funding - Summer 1985, three cycles ending April 1989
- Total funding level, $1.5M.

PTRA Obligations
- Present at least two workshops/year
- Attend as many of the national meetings as possible
- Serve as a resource for teachers in own geographical area

Major Influences
- Host of new workshops for AAPT
- Work with teachers at all levels
- Catalysts for a wide variety of other programs
- Provide a major influence within AAPT
- Present many papers and workshops at national meetings
- Publications in a wide variety of magazines and journals
- Recognition by selection in many other program
  - Presidential Award recipients
  - PRISM project members
  - Woodrow Wilson Fellowships

Evaluation

The AAPT has a major obligation, as the perpetrator of this first of its kind program (PTRA), to carefully document the experiences and outcomes of the program, so that other disciplines who might choose to provide similar programs to improve science and math education may

The AAPT asked Inverness Research Associates to provide external evaluation of the PTRA program. This evaluation is in its final stages of completion. The mechanism chosen was a comprehensive survey made up of questions and items based on other national documents dealing with high school physics teaching as well as statements and questions derived from focus group discussions held by small groups of PTRAs at the last three national AAPT meetings. The survey now has an 80% return level which assures us that we have responses from very active as well as some who have been relatively or completely inactive. This will enable us to provide an accurate, independently derived picture of the characteristics of the program for the NSF, for other professional societies, and for the community at large.

A Summary of Preliminary Findings of the survey as of June 1989 is provided as the last part of this document. Major points from these results are that a PTRA like program is an effective way of reaching large numbers of teachers. In the area of physics, it is critical to understand that many of the teachers of physics are persons who are crossover teachers from another discipline who need help in developing teaching techniques in physics. In the case of middle school and elementary teachers, they can discover that there is a lot of elementary physics that

Professionals

Those PTRAs who emerged as active members of the group clearly have an identity that has given them permission, encouragement and the power to work with others to build a community of teachers who are concerned with the quality of science at all levels in our schools. The major aspect of the program that allowed this to occur was the ability to continue support for all active PTRAs through the funding period of the 1987 grant. After their initial summer training and after carrying out their activities back in their own areas, PTRAs were able to attend the summer and winter AAPT meetings to compare notes on their individual accomplishments and to gain new ideas. This was probably the key accomplishment, the emergence of professionals in helping others deal with physics who were given not only a title but the physical resources to serve as a professional.

The Future

Most PTRAs said that they could continue indefinitely in their PTRA roles if they had financial support and opportunity for interaction with each other. It will be important for AAPT to plan sessions at each of their winter and summer meetings for PTRAs as well as at the NSTA national and regional meetings. It is less assured that teachers will be able to find local financial support. Many have succeeded in utilizing local resources such as Title II and private sources, but this may not enable them to attend the national meeting renewal sessions so important to their success.

We all agree that we have not addressed the involvement of minority teachers in a program such as PTRA. This must be addressed in the near future. It should be noted that women comprised 21% of the PTRAs.

We all agree that this would be a valuable program in other areas such as chemistry, biology, earth sciences, and mathematics.

Summary Comments and Recommendations

Project Interactions Support

A common element in both programs is the long term interaction between all parties involved. A single summer institute of limited duration does not develop the professional that emerges as the result of a longer interaction typical of these two programs. Teachers need time to return to their classrooms, carry out the work associated with the program, and then return to fine tune the elements and professional interactions that can only occur after the intervening personal experiences.

At a recent NSF project directors workshop (June 1,2,3), about 60% of the directors in one discussion group felt that grants did not at this time allow enough money to support classroom visits and interactions as programs are being carried out. This is a critical element in building a set of professionals whose interaction and mutual support will continue

Project Research Components

Each program needs a research component to compliment the teacher enhancement activities. In the case of the MBL project this involved monitoring both the progress of the teachers and the students. In the case of the PTRA program, this involved tracking the activities of the resource agents, but did not reach to the level of that PTRA's classroom nor any direct assaying of the teachers who enrolled in the PTRA's workshops, nor the administrators with whom these teachers interacted to carry out their programs or returned to work under after obtaining their training.

A proposal was prepared to extend the PTRA evaluation to this level, but was not funded. Serious and detailed evaluation does require adequate support levels within each proposal.

Project Program Officers

During the life of each of these projects there have been changes in the program officers assigned to the projects. If research shows that longer term projects are likely to be the most effective, then stability in the program officer assignments must be insured. The two year rotator positions almost guarantees a limitation on NSF's ability to do this.

Science Instruction in the Schools

We have often focused on the students and their shortcomings and not often monitored the backgrounds and skills of our inservice teachers. When we have, it has often been with an examination, which if not passed, results in dismissal of the teacher. We in the university community could do much more to insure firm conceptual understanding by changing the way we work with inservice and preservice teachers. A true collaborative venture would allow us to monitor each teacher's conceptual development, create learning settings to bring about changes, and provide our community with teachers able to do the same for their students. There were suggestions at the recent NSF Project Directors workshop, that the NSF would seek evidence that programs designed for teachers would themselves model the teaching strategies and behaviors that we wish teachers to employ with their own students. This would be a marked improvement.

AN EVALUATION
OF
THE PHYSICS TEACHING RESOURCE AGENT PROGRAM

A SUMMARY OF PRELIMINARY FINDINGS

JUNE 1989

THE NEED

A recent American Institute of Physics (AIP) report[1] provides a detailed picture of the individuals who are teaching high school physics and the conditions in which they work. Central to understanding the rationale and impact of the PTRA program are the following report findings that illustrate the current status of high school physics teaching:

- Only 25% of physics teachers have a degree in physics. Most individuals teaching physics today are "crossovers". Only 13% of all "physics" teachers teach only physics. Two-thirds have their primary concentration of classes in fields other than physics (e.g. math, chemistry...).
- High school physics teachers are very isolated from each other. 90% of all public high schools have only one physics teacher, and only 10% of them report frequent contact with physics teachers at other high schools. Two thirds of all physics teachers want more professional contacts.

In agreement with the AIP study, the PTRA participants told us that the most pressing needs facing physics teachers today are:

- the need for an improved teaching climate and conditions (e.g. lower class size, more prep time, fewer preps, etc.) (68%)
- the need for professional challenges and opportunities for development (57%)
- the need to share and interact with other physics teachers (52%)

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[1] Neuschatz, M. and Covalt, M.: Findings from The 1986-87 Nationwide Survey of Secondary School Teachers of Physics, American Institute of Physics, New York, NY. (1988)

THE PTRAs

The PTRA initiative aims to recruit the most skilled and committed career physics teachers and develop them into a self-supporting cadre of "resource agents" -- a group bonded by a shared mission to help their less prepared colleagues.

Nominated by their peers, and chosen on the basis of their commitment and experience, approximately 300 PTRAs have been trained from 1985 until the present.

- They range in age from 26 to 64, with an average age of 45.
- As a group they collectively have five thousand years of experience teaching physics, averaging nearly sixteen years each. Only 8% of the PTRAs have less than 10 years teaching experience.
- They are 98% white with only 2% Asian and 1% black. There are no Hispanic PTRAs.
- One quarter (26%) of the PTRAs are female.

The PTRAs teach in schools which they feel are best described as:

- suburban (71%), middle class (58%), upper middle class (53%), white collar (46%), ethnically mixed (30%), rural (29%), poor (25%), blue collar (27%), urban (12%), and inner city (9%).

THE WORKSHOPS OFFERED BY THE PTRAs

According to the in-house AAPT records, each PTRA over the course of their PTRA career has on the average:

- devoted 8 hours each month to PTRA activities.
- given 8 workshops with an average length of 5 hours.
- worked with 26 participants in each workshop.
- involved a total of 237 participants in their workshops.

Thus, as a group the PTRAs over the last four years have collectively:

- provided workshops for over 60,000 teachers.
- provided a total of 280,000 interaction hours.

ISSUES FOR THE PTRA PROGRAM

The issue of under-represented groups in science and mathematics raises the concern of the PTRAs in at least two ways:

- Only 12% of the PTRAs feel that there is an appropriate proportion of minority PTRAs; 62% feel that the proportion of women is appropriate.
- Only 13% of the PTRAs feel that the program significantly addresses the under-representation of the minorities in the sciences.

There are several other facets of the program that raise concerns for many of the PTRAs:

- A major concern almost all the PTRAs share is the termination of funding and premature demise of the program.
- The program is clearly successful at helping individual teachers but may be less successful at influencing state or district administrators. Only 25% of the PTRAs thought they had gained the attention of school administrators and raised the priority of physics teaching within the local district. Only 10% thought they had influenced state-level support for physics teaching.
- Only 13% of the PTRAs felt that the program increased their involvement with university and research scientists.
- Nearly half (49%) the PTRAs are concerned that the program reaches and works best with those teachers who are already very good and thus "just helps the rich get richer".

THE PTRAs' OVERALL EVALUATION OF THE PROGRAM

Two-thirds (67%) of the PTRAs feel that there are very few (or no other) programs that offer similar opportunities to those made available by the PTRA program.

80% say that the PTRA program has had a large or major influence on their overall career.

In judging the overall value of the program PTRAs gave the highest ratings to its:

- personal value to them as professionals and teachers (74%)
- value to the overall physics teaching community (67%)
- value to their own students (47%)

In terms of serving the overall physics teaching community, PTRAs felt their most important contributions included:

- developing a network of teachers with a shared interest and commitment to physics teaching (83%).
- helping to overcome teacher isolation (76%).
- helping under-prepared or reassigned teachers (69%) to improve their confidence, self esteem, and motivation to teach physics.
- helping elementary and middle school science teachers (33%).

COST-EFFECTIVENESS OF THE MODEL

As a group the PTRAs collectively have provided:

- approximately 75,000 hours of PTRA service to date[2].
- workshops for over 60,000 participants.
- a total of 282,000 participant-hours of instruction[3] .

The PTRA participants themselves strongly believe in the PTRA model:

- 88% of the PTRAs feel the program is a highly cost-effective use of NSF's money.
- 98% said that if they were NSF program officers entrusted with spending public money, they would invest in a similar program for Chemistry and Biology.

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[2] If one were to consider all of the NSF grants to the PTRA program as payment to the PTRAs for their services, then the PTRAs have been working at a rate of approximately $5 per hour.

[3] The 282,000 participant hours of instruction, if funded entirely by NSF (including participant stipends and instructor costs at normal NSF rates) would cost approximately 7 million dollars. The PTRA lead teacher mechanism, by these calculations, yields an approximate 5 to 1 leveraging of NSF funds.

THE FUTURE OF THE PROGRAM

The PTRAs are a highly skilled, committed and enthusiastic group of teachers who are now positioned to offer assistance to their colleagues:

- 82% say they could continue indefinitely in their PTRA roles if they had financial support and opportunity for interaction with each other.
- 60% want to continue as PTRAs at an increased level, 35% at the same level, and only 6% at a reduced or no level.
- Only a small proportion of PTRAs felt that they suffer from "burnout" (16%), lacked confidence (1%), or became disheartened (8%).

To continue their work as PTRAs they say that what they need most is:

- financial support to participate in the national meeting[4].
- national leadership for the program.
- funds for workshops and local/regional activities .

The prospects of getting local support seem mixed at best:

- Only 25% of the PTRAs feel that it very likely that they would be able to generate local or state support for their PTRA activities.
- 15% feel that such local support is very unlikely.
- The remaining 60% feel such support may be possible but they have not explored it enough to be sure.

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[4] 81% of the PTRAs agree with one PTRA's statement that "the key ingredient to our future support is that we all have funding to attend the national meetings...This is where we get our batteries charged... I personally don't think that PTRAs will continue without the follow-up contact and support..." Without PTRA support 85% of the PTRAs say that they would be able to attend far fewer or no AAPT national meetings.

Mr. **Walgren**. Thank you, Dr. Layman. We appreciate that testimony.

And we'll turn, then, to Ms. Ware.

Ms. **Ware**. Mr. Chairman, and members of the committee, my name is Sylvia Ware and I'm director of education at the American Chemical Society. As such I'm responsible for the womb-to-tomb programs we now have in place to address the many problems in science education now facing our Nation. I'm delighted to have the opportunity today to talk to you about one of my 15 programs, the "Chemistry in the Community" curriculum, or ChemCom for short.

ChemCom is a year-long chemistry course that was originally designed for high school students who had not made any decision for the sciences as a career. In other words, the majority of our students, who will feel are not currently being serviced very well by the type of traditional chemistry courses that are being taught in the majority of our classrooms.

In practice, we have found that when we get ChemCom into the schools that we are beginning to get more students interested in taking chemistry as a result, and going on to take a more traditional second year in the high school and going on to major in chemistry in the colleges. So, although we are servicing our literacy function, we do appear to be doing more than that. We do appear to be feeding the pipeline.

ChemCom began in 1981 with an initial grant from the National Science Foundation of $193,000. There was a hiatus in 1982-83. In '84-85, we received additional funds from the National Science Foundation that permitted us to finish development of the curriculum; and, if you have not seen copies of the curriculum, I do have the book and the teacher's guide here. The amount of money put into the development of ChemCom by the National Science Foundation was about $663,000. The Society put in about $320,000 over the same period of time.

ChemCom differs from traditional courses in that we have decided that it is very appropriate for many students to teach chemistry on a need-to-know basis, rather than starting with the structure of the discipline and teaching it in the same fashion as we've been teaching for the last 20-25 years. If the need to know a particular branch of chemistry, a particular concept in chemistry, cannot be established, then we don't teach it.

The course is structured around issues in the community involving chemistry. These issues covered are: supplying clean water; conserving chemical resources; utilization of petroleum as both a fuel and a chemical feedstock; feeding the world; nuclear energy production, isotope utilization and waste disposal; air pollution; health as a state of chemical balance in the body; and the role of the chemical industries in our society.

The course covers less physical chemistry than a traditional course, but more organic and biochemistry. There is less mathematics, but more decision-making exercises that are never found in the traditional books. The course requires about 50 percent of the time in the lab. It is probably less expensive to implement than the more traditional courses, requiring no special equipment or chemicals.

Individual ChemCom units were field tested as infusion material in existing courses in 1982-83. Following a year of rewriting, a year-long field test was held in the '85-86 school year. Teachers from 13 States participated in this, with approximately 2,900 students. Most of our teachers attended workshops sponsored by ACS with funds from the National Science Foundation, though we did have a few teachers who were just given the book and the teacher text and told to get on with it. We did find as a result of this experience that because of the very different nature of this course we do need to provide significant teacher training.

At present, we are engaged in a multi-year effort to provide two weeks of summer training to those teaching ChemCom for the first time. Like Dr. Layman, we are pursuing the teachers training teachers model. The teachers that we see will be ChemCom in-service resource teachers capable of teaching the same kind of things that we've taught them to teachers in their own community. The National Science Foundation is providing some $550,000 for this particular effort, while the American Chemical Society is supporting not just the 3-year effort that is funded by the National Science Foundation, but an additional four to five years of teacher training, for a total commitment of $1.4 million. And we are raising this money from the chemical industry and from our own membership in the capital campaign that we are currently undertaking. So the NSF money is doing a marvelous job in helping us leverage our own members. In fact, without the support of the National Science Foundation, both for the development of our material and for the teacher training, I very much doubt if we would have been able to initially convince the chemistry establishment that this was a valid way to go in the teaching of chemistry. And I am personally extremely grateful to the NSF for their support of this rather different project.

The need to provide as much support for teachers as possible for this program has led the Society to develop a national electronic bulletin board called ChemComNet, and we also have a newsletter that we publish twice a year for about 8,000 teachers who are on our mailing list, that keeps them up-to-date with what is going on in the ChemCom community, and this one is ChemComments. I'm kind of doing the ChemCom bit to death, I'm afraid.

There is a concern amongst the teaching community that they do have to get their students through a standardized exam. The American Chemical Society is solving this particular problem by developing our own standardized test, and our test will be available in two years. We do already have a test that matches the more traditional courses. This new test will not only cover the chemistry content, but give us an opportunity to look at the ability of our students to apply the knowledge in problem-solving situations and to, perhaps, apply the knowledge in new situations to which they've not been directly exposed in the classroom. The Society is also planning to develop video material both to integrate with the classroom material and for use as in-servicing of teachers where we don't have a resource teacher available to help. This also will be paid for by the Society through our current capital campaign.

And then the final ChemCom project that we are involved in is our college ChemCom course, and we are beginning, this summer, to develop a one-semester course for upper division college students that will continue the same kind of philosophy and approach as ChemCom.

The text has been adopted or placed on an approved list in 11 States. This is our first year of going through the approval situation, and we have been very successful. We will seek other adoptions as the adoption process cycles into the individual States.

ChemCom was rejected for State adoption in three States. The reasons for its rejection can be explained by its completely different approach to chemistry. Existing book adoption criteria in some States may be inappropriate and irrelevant to a proper evaluation of ChemCom. Indeed, in some States the textbook adoption process may eliminate from consideration any new book that doesn't look exactly like the rest, all of which tend to blur together in content and approach in each of the sciences. And, in fact, the American Chemical Society will be producing a report this year from its Committee on Education suggesting that we have too many "vanilla" texts in chemistry, all of them weighing more and more each year, at both the high school and the college level, and perhaps what we need is a little more of an idiosyncratic approach to chemistry so that the enormous flavor of the subject gets across to a wider number of students. At present, our high school students seem to equate chemistry solely with mathematical manipulation.

If ChemCom did not have the backing of NSF and ACS, I doubt if it would have been as well accepted as it is today. Since January, when our first—of '88, when our first commercial edition was published by the Kendall-Hunt Publishing Company until now, we have sold 37,000 books in over 40 States. ACS is now beginning to develop the second edition of ChemCom with royalties received from book sales.

ChemCom is not liked by high school teachers who believe that high school chemistry should be a duplicate of first-year college chemistry; and, unfortunately, there are many high school teachers—not all, but many—who take this particular tack. However, perhaps as many as a third of the teachers out there have been waiting for ChemCom for many years. Students find it an intellectually challenging and intellectually playful course. They also have an opportunity to experience success in the chemistry classroom. The lack of success that many students are currently experiencing in the classroom is no doubt contributory to their general attitude of dislike for the course. More than that, they do know why they are learning the chemistry, and they know that much of what we teach them they will use as citizens in our society when they will have to make many decisions that do require at least a rudimentary knowledge of chemistry.

An additional barrier to acceptance is at the college level. Not all colleges will accept ChemCom as the required chemistry course for college entrance, and remember we are talking about students here who are not planning to go on in the sciences, necessarily. Many colleges have no problem with accepting the course because they have looked at what we are trying to do and they have met our students. In fact, there is one university I know of in the State of Washington that is going to teach at conventions and actively try and to find the ChemCom teachers because they want to specifically recruit their students into chemistry. They go into college with a basic knowledge chemistry and an enthusiasm for chemistry that is, unfortunately, all too rare.

Clearly, we have a long way to go before it is possible to declare ChemCom an unqualified success. Hopefully, other publishers will be encouraged by our efforts to attempt to explore different approaches to the teaching of introductory chemistry. Not necessarily our approach, but even more imaginative and mind-developing courses. And, if there are any publishers in the audience here, I challenge them to start thinking in that particular direction.

I would like to conclude my remarks by emphasizing that the American Chemical Society does not consider ChemCom to be a watered down approach to introductory chemistry, but merely a different approach, likely to appeal to a wider and more divergent group of students than traditional offerings. It is not the only way to teach chemistry, but it is one way with which we are having some success. If we do not make that initial exposure to chemistry more interesting and more appropriate to the cognitive development of the majority of our students, then chemistry could follow the dodo into extinction.

Thank you.

[The prepared statement of Ms. Ware follows:]

STATEMENT
of the
American Chemical Society

STATEMENT
of
MS. SYLVIA A. WARE
on behalf of the
AMERICAN CHEMICAL SOCIETY
to the
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
on
ChemCOM
WEDNESDAY, JUNE 7, 1989

Mr. Chairman and Members of the Committee:

My name is Sylvia A. Ware. I am Director of the Education Division of the American Chemical Society (ACS), the world's largest scientific organization. As Director, I am responsible for the range of "womb-to-tomb" programs now in place at the Society to address the many problems in science education which now plague our nation, and threaten our future economic survival. I am pleased to appear before you today to discuss just one of the Society's 15 educational programs, the "Chemistry in the Community" curriculum, or ChemCom for short.

ChemCom is a year-long chemistry course originally designed for high school students who, although they may be college bound, have little or no interest in any of the quantitative disciplines. While the course very ably serves its original chemistry literacy function, the ACS has found that, in practice, it also is motivating more students to consider careers in chemistry. Thus, it is feeding the pipeline.

ChemCom began late in 1980 with a visit to the National Science Foundation (NSF) by the ACS manager of High School Chemistry. At this meeting the Foundation staff expressed an interest in supporting a new approach to high school chemistry teaching. The initial NSF ChemCom grant of $193,000 was awarded in late 1981, in the last funding cycle of the NSF Education Directorate prior to its 1982-83 hiatus. Additional NSF grants awarded in 1984 and 1985 permitted the American Chemical Society to complete the project. The total NSF support for ChemCom development amounted to $663,000. The American Chemical Society contributed approximately $320,000 over the same period. However, without the initial support of the Foundation, it is doubtful that there would be a ChemCom course today. The Foundation not only provided money, but moral support for a very different approach to chemistry.

Unique Nature of ChemCom

ChemCom differs from traditional courses in that it teaches chemistry on a "need-to-know" basis only. If the "need-to-know" cannot be made explicit to the student, then the chemistry is left out. The course is structured around issues in the community involving chemistry, rather than around specific chemistry concepts. The issues covered are: supplying clean water; conserving chemical resources; utilization of petroleum as both a fuel and a chemical feedstock; feeding the world; nuclear energy production, isotope utilization and waste disposal; air pollution; health as a state of chemical balance in the body; and the role of the chemical industries in our society today.

The course covers less physical chemistry than a traditional course, but more organic and biochemistry. There is less mathematics, but many decision-making exercises are given that never have been found before in traditional texts. The course requires that about 50% of the student's time be spent in laboratory activities, yet ChemCom is less expensive to implement than a more traditional course, requiring no special equipment or chemicals (other than those purchased at the supermarket or drug store).

From the beginning, ChemCom was designed by high school teachers with guidance from college-level chemistry educators. Prominent chemists from academe and industry reviewed the technical content, but did not dictate either the format of the course or its specific content. Individual units were field tested as infusion material in existing courses in 1982 and 1983. Following a year of rewriting, a year-long field test was held in the 1985-86 school year. Teachers from 13 states* participated in the field-test involving over 2,900 students. Most teachers attended ChemCom workshops, although a few were only provided with the student and teacher texts. Feedback received from the field-test made it clear that the ACS would need to offer workshop support to ensure widespread acceptance and usage of the final text.

Teacher Support Activities

At present, the American Chemical Society is engaged in a multi-year effort to provide two weeks of summer training to those teaching ChemCom for the first time. These teachers are being trained to serve as ChemCom in-service resource teachers in their own, and adjacent, school districts. The NSF Science and Engineering Education Directorate is providing some $550,000 to support a three-year training effort. The ACS is providing $1.4 million to match the NSF support, and to continue teacher training for an additional four or five years. These funds are being raised from industry and the ACS membership. The publisher of ChemCom, Kendall/Hunt, also supports an additional 50 one to two-day workshops per year. This summer, 100 resource teachers are being trained at the University of California-Berkeley; the State University of New York-Cortland; the University of Houston; the Colorado School of Mines; and, Mount Union College, Ohio.

The need to provide support for new ChemCom teachers has led to the development of a national ChemCom electronic bulletin board, "ChemComNet," with free access available to any interested teacher. "ChemComNet" is run out of Oklahoma State University. Twice a year, the ACS also provides a free ChemCom newsletter called ChemComments, again to all interested teachers.

Some teachers have expressed the concern that their students are required to pass a standardized chemistry test and hence cannot take ChemCom. To address this situation, the Society, through the Chemical Education Examinations Institute (run by the ACS member Division of Chemical Education), is developing a "ChemCom" standardized examination. The examination, which will not be available for about two years, attempts to test the students' ability to think critically, to synthesize and apply knowledge, as well as to understand concepts and retain material. The Society also will be experimenting with a computerized version of the exam.

The ACS also is planning to develop "ChemCom" videos for both classroom enrichment and teacher in-service training, using funds raised from industry and ACS members. This summer, recognizing the importance of a similar approach to chemistry for older students, the Society will begin to develop a one-semester, college-level "ChemCom" course.

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* California, Colorado, Hawaii, Iowa, Illinois, Louisiana, Maryland, New Jersey, New York, Texas, Virginia, Washington, Wisconsin.

Since January 1988, when the first commercial edition of ChemCom was published, until now, sales have exceeded 35,000 books in over 40 states.* ACS is now beginning to develop the second edition of ChemCom with royalties received from book sales.

The Adoption Process

The book has been adopted, or placed on an approved list, in the states of Georgia, Illinois, Kentucky, Michigan, Missouri, Ohio, Oklahoma, South Carolina, Utah, Indiana, and Louisiana. Other state adoptions will be sought as soon as chemistry texts are considered routinely for adoption in these states. For example, upcoming state adoptions in 1989-90 are Alabama, Arkansas, Idaho, North Carolina. In 1990-91, they are Arizona, Florida, Tennessee. The state adoption effort is conducted by the text's publisher, Kendall/Hunt. (Incidentally, Kendall/Hunt was the only publisher of the ten invited to cooperate with ACS on this project willing to leave the Society with copyright and editorial control.)

ChemCom was rejected for state adoption in Oregon, Mississippi, and Virginia. The reasons for its rejection can be explained by its completely different approach to teaching chemistry. Existing text book adoption criteria in some states may be inappropriate, and irrelevant, to a proper evaluation of Chemcom. In some states, the textbook adoption process eliminates from consideration any new chemistry text that doesn't look exactly like existing texts--all of which tend to blur together in content and approach. The same is true for the other sciences--the educational system is very nervous of curriculum innovation. If ChemCom did not have the backing of NSF and ACS, it is doubtful that the text would be as well accepted as it has been.

The Society also has discussed changes in traditional chemistry curriculum. Last November last year, the ACS Society Committee on Education met at Western Maryland College in Westminster to discuss factors driving the introductory chemistry curriculum. General concern was expressed about the similarity, blandness, and weight of texts at both the high school and college levels. An upcoming report from this conference includes a plea to authors and publishers to produce more chemistry books of "character," even, perhaps, of an idiosyncratic kind. Chemistry is a much more vital, interesting, and varied enterprise than is currently revealed to students in high school.

Others Barriers to Success

ChemCom is not universally loved by high school teachers, especially those who believe high school chemistry should be a duplicate of first-year college chemistry. However, a substantial cadre of high school chemistry teachers, perhaps as many as a third, have been waiting for ChemCom for years. Students find it an intellectually challenging and enjoyable course. More than that, they know why they are learning chemistry, and they know they will use much of what is taught them throughout a lifetime (see Appendix). Some community colleges are using ChemCom, as well as some graduate science education programs. It also has been suggested that ChemCom may be a useful approach to chemistry for journalists--or even future politicians--to learn chemistry!

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* The top 10 states in terms of sales are (from highest to lowest): Washington, Colorado, New York, Ohio, Florida, California, Illinois, Pennsylvania, New Jersey, and Virginia.

Another barrier to acceptance is at the college-level. Not all colleges will accept ChemCom as the required chemistry course for college entrance, although many do with no problems whatsoever. The ACS will need to inform all of the college community that ChemCom is a rigorous course that is more than adequate preparation for any college freshman chemistry course. No college instructor who is familiar with the course, and has met a ChemCom student, has any doubts in this regard.

Conclusion

Clearly, the Society has a long way to go before it is possible to declare ChemCom an unqualified success. Hopefully, other publishers will be encouraged by our efforts and attempt to explore different approaches to the teaching of introductory chemistry--not necessarily our approach--but even more imaginative and mind-developing texts. Other disciplines already are watching ChemCom's progress with a good deal of interest. For example, several of the professional physics societies are considering the possibility of developing the physics equivalent of ChemCom. Contingent upon funding, the ACS is planning to develop a three-year integrated science course from grades seven through nine that shares the ChemCom philosophy and approach.

The world wide interest in ChemCom is very gratifying. We have conducted ChemCom workshops in Great Britain, Australia, India, Hong Kong, Finland, France, Brazil, Canada, and Denmark. The Society has received requests for permission to translate ChemCom into Spanish and German. Since the community context of ChemCom is peculiarly American, this many not be an especially good idea. Certainly the text could be rewritten for different cultures. The possibility of redesigning ChemCom for specific developing countries also has been under consideration at ACS so that "appropriate" technology can be accompanied by "appropriate" education.

The American Chemical Society does not consider ChemCom to be a watered-down approach to introductory chemistry but merely a different approach, more likely to appeal to a wider and divergent group of students than traditional offerings. It is not the only way to teach chemistry, but it is one new way with which the Society is having some success. If the ACS and others do not make that initial exposure to chemistry more interesting and relevant to the cognitive development of the majority of our students, chemistry may, like the dodo, become extinct.

Appendix

Appendix

Selected Student Comments

"Until I enrolled in this course I was never aware of how much science, especially chemistry, involves the political world. I used to think that sciences were just those classes that you needed for college preparation. I now realize this was a misconception. Chemists, biologists, and physicists play an extremely important role in society."

Corey Wilkins
Sumner High School, WA

"We learned how to apply chemistry to real-life situations. We learned material in a fun way, not by just boring lessons and memorization. ChemCom makes learning chemistry logical, how it can be used and applied to real life. A regular chemistry class has the attitude of, 'Here it is, learn it, memorize it.' A regular chemistry class is similar to a math class--we learn it but don't know how to use it in real life. I think ChemCom is an appealing way to approach chemistry and should be modified to other subjects. I feel special being a student of the new ChemCom class."

Unnamed student
Cy Fair High School, TX

"ChemCom focuses on the most important facts in chemistry, not like regular chemistry classes. I feel that in years to come, I will still remember what I am learning now. I really like ChemCom and I'm sure that it will be a great help to me in the future."

Unnamed student
Cy Fair High School, TX

"I don't like science at all, but this book tries to make it interesting. The fish kill unit was totally exciting."

James Barnes
Rolla High School, MO

"It's a great class because it allows us to relate chemistry to the environment around us and it enables us to solve problems in the community with the things we learn in this class. They're not just teaching us to be chemists; they're teaching us to be problem solvers."

Mark Hines
Peninsula High School, WA

Selected Teacher Comments

"It benefits the students greatly because everything is related to real problems. They will be able to use their knowledge of chemistry later in life."

Phyllis Murray
Freeman High School, VA

"Teaching ChemCom is very different from teaching the traditional chemistry course that I have taught for the past four years. My ChemCom students, while working in small-group activities, do think and present their ideas to group members without being pushed and prodded by me. In fact, my students get so involved that they ask to continue the activity a second day! Even the student who would not usually contribute in an entire-class setting will participate in these small-group activities.

The ChemCom text is interesting and quite easy to read. One of my fellow chemistry teachers remarked, 'The ChemCom text reads like a good novel.' Many of my students feel that way too; they even read ahead! They are beginning to discover what an important role chemistry plays in their lives and how chemistry relates to real issues. One of my school district's goals is to develop students into independent learners. ChemCom is doing just that!"

Betsy Ross
Grand Island High School, NE

"As a member of the ChemCom family, I know I speak for all of us when I say that the philosophy and thrust of ChemCom--the problem-solving, decision-making, and hands-on lab approach--works extremely well in our chemistry classes."

Vincent Bono
New Dorp High School, NY

"When I was asked, 'Do you want more books next year or not?' I went to the students and asked them specifically. 'You're the people talking to other students. What do you think? Will there be more students next year? Will there be enough to make make up a class? What will happen?' Unanimously they told me, 'Go get more books.' It has turned out to be exactly that way. We just got the numbers in, and we've gone over this year by twice the number of people. The students were right--they were talking and that has been a very positive thing in our school. I think ChemCom has done exactly what it started out to do: to make people not afraid of chemistry, but interested in it."

Michael Ironsmith
Fairpark High School, LA

American Chemical Society
June 7, 1989

BIOGRAPHY

Sylvia A. Ware

Sylvia Ware is the Director of the American Chemical Society's (ACS) Education Division. She joined the Society eight years ago as the first manager of the Office of High School Chemistry; later, she became head of the Division's Educational Services Department where she was responsible for such successful programs as the International Chemistry Olympiad, CHEMCOM (Chemistry in the Community), CHEM MATTERS, Academic/Industrial Education, the Student Affiliates program, and Two-Year College Chemistry.

Mrs. Ware was born and educated in England. She received her bachelor's degree in industrial chemistry from the University of Manchester, England. Before coming to the United States, she worked for Imperial Chemical Industries' pharmaceutical division where she conducted research on beta-blocking agents. She spent three years in Sierra Leone, West Africa, where she taught chemistry for British university entrance, and physics and biology for the school-leaving examinations of the West African Examinations Council. She taught an additional five years of chemistry and physical science in schools in Atlanta, Georgia, and Washington, D.C. She also worked as a consultant to the U.S. Environmental Protection Agency for four years.

Mr. ROE. If Members of Congress don't start paying attention to improving the technical educational program, Members of Congress may go the dodo bird route, too.

[Laughter.]

I want to thank you very much, Ms. Ware, for your splendid testimony.

And our next witness is Mr. Barry Stebbins, West High School, Columbus, Ohio, accompanied by Mr. Sadi Chhoa—was my pronunciation okay?

Mr. STEBBINS. "Cho-ah."

Mr. ROE. "Cho-ah"—and Mittie Cheatham.

Mr. STEBBINS. Thank you, Mr. Chairman, members of the committee. I would first like to ask that a packet of information explaining what ACOT—Apple Classroom of Tomorrow—is all about. I will give you a very simple explanation. ACOT is a long-term educational research partnership—and the keyword there is the word "partnership"—involving several schools around the country and the Apple Computer Corporation.

I'd also like to take this time to thank you for the opportunity to testify about a major problem we have in education and suggest a possible way that that problem can be answered. We are having a great deal of success with this ACOT program at West High School in Columbus, Ohio, and I'm going to talk about why we think we're successful and something that we've done that's entirely different than I think is being done anywhere else.

We realize that the problem is that we've turned students off to education. We have bored them with the traditional, teacher stands in front of the classroom and lectures and the kids sit there and listen, and that doesn't seem to be working.

When we started this program we looked at the fact that we thought our students were approaching a new age, an information age, and they were no longer going to be in an industrial age. So that our presentation shouldn't be an industrial age presentation; it should be an information age. What is an information age?

Well, information age presentation means the students learn to deal with information. They can analyze information, they can make decisions, and when they come out all of the educational skills from all the various classes must fit together in a very holistic approach. As we started this, we came up with a term that we like to use, and we refer to our classroom as a community of learners. In that community teachers and students have an equal stake in what is going on.

We entered this project and were given a computer that we knew very little about. We did know that there was not a lot of educational software out there for this particular computer. We were using the Apple MacIntosh computer. So we as teachers quickly had to figure out how we were going to go about using this computer. We role modeled problem solving to our students.

The students and the teachers ended up sharing a learning experience. Students saw us teachers as learners in this classroom. We also felt that our students should walk away from this experience with some skills that are real life skills. They should have developed some—learned to use some tools, developed some skills that would take them into the 21st century.

Now, I realize that we're talking about math and science, but let me first say that in this classroom we in a sense became a one-room schoolhouse. We brought an English teacher in. We brought a social studies teacher in. Myself, a science teacher, and a math teacher. And we felt that most important thing we could do for these kids was to integrate all of their subject areas into this one program. We didn't shorten the amount of time each teacher got to spend with the students, but we did something that has not happened in a high school.

From the math-science point of view, I'm in the classroom for the math teacher. I support the math teacher when math activities are going on. The math teacher supports me when science activities are going on. We had a very big bias. Science cannot be done without math, and science has a lot of opportunities to help reinforce what is being taught in math. Science also has a lot of opportunities to reinforce what is being taught in English and social studies, as well.

So, as we approached this we looked for a new way of meeting these goals. We found that in science classes students weren't successful because they couldn't do the math kind of operations we wanted. We also found science students weren't successful because we didn't give them enough lab opportunities, enough hands-on, as you've heard other members testify—other witnesses testify here.

We took a team approach. We looked at the curriculum in all areas and sought to rearrange it so it fit together in a more appropriate manner. For example, when in science we teach about Newton's laws there are many formulas that the students need to learn to use. One of those formulas is simply "force equals mass times acceleration." There are three components to that formula. If the students do not know what order those are put in or how to manipulate the order that they are going to use those, then they're lost in that concept.

So we first we talked about how does the math teacher explain variable manipulation in an algebra class—and notice I said algebra. When we started this program we assumed that all students could handle algebra. We did not choose students who were identified as algebra candidates. Half of our class was signed up for general math. Our students were very successful in algebra because we had two teachers working in the classroom at the same time. We set up experiments which reinforced those concepts. We went to a lab, we collected data, we came back and used the data. Now I didn't do that as a teacher; my students did that. My students were involved in that learning process.

So our whole goal was to see education as a holistic approach. What they learn in math was important to what they learn in science. Communicating with their fellow students was a very important thing. We need to be able to communicate if we're going to succeed in tomorrow's world. So the skills they learn in English class were also put to use in that science class, in that math class, in the social studies class.

Another thing we found that was very important was to give kids an opportunity to create a major piece of work that they had ownership to. We did that in several ways. The first way I am going to talk about was a biology project. We covered the concept of taxonomy. In the whole Modern Biology textbook there are 26 chapters, and Holt suggests I spend 10 to 12 days per chapter to cover that material. Well, if you do the quick math you know that the school year isn't as long as the number of days suggested. So, to get through this material, I assigned groups of students to cover certain sections.

The students worked, collaborated, communicated, researched, and came up with a presentation that they gave to their fellow classmates. They determined which material was most important. So when this material was presented to the classmates, I was a fellow teacher with my student, or students, in presenting that material to the classroom. It was a cooperative effort and everybody had a part. Each person's part in that classroom was important to the whole project. You are going to see two of my students talk about that biology project as they demonstrate what their part in the project was.

In another project we built a working model of downtown Columbus. This started out as a robotics project in a computer applications class. The first thing we found out was the students had to know about electricity and circuits and all those things from science. So all of a sudden the computer applications teacher depended upon a certain knowledge base coming from science, and we actually went hands-on and put this together.

Then somebody suggested that we have a couple models of a building. All of a sudden somebody else said, "Well, let's build downtown Columbus," which was a very high-tech-type of situation. We looked at downtown Columbus, what did we need to know? We needed to know which buildings were important, what the name of those buildings, what went on in them. Students researched that. They wrote it up. English and social studies skills were used.

Then we got to building the actual buildings, and we found that we had to buy FormCor board to build these. It is a very cheap material, but it was 40 inches high, so we made the assumption that the tallest building would be 40 inches. Now we had to scale all the rest of those buildings to that dimension. So all of the proportion, the scaling, the angles—the geometry that had been learned in math class was brought to this project. Eventually, all the teachers were involved in solving this project. It was a realistic approach, hands on. When there was a problem with the robotics stuff—first major problem we had was that the instructions were in German and none of us spoke German. So we had to figure out how to solve this. The kids worked together. They worked through the process. They came up with creative solutions. When it didn't work they went back to the drawing board.

Now what is this process I've just really explained? Every science textbook that I have looked at talks about something called the scientific method, and my Modern Biology book takes a page and a half to explain that. My physical science book takes two pages. We have a chemistry book in our high school that takes three pages. Now where do they talk about the scientific method? In the first week of September, and then we forget it. And then we go on and do recipe-type approach to education.

Scientific method is, I think, probably the answer. You've heard other people say that today. The research, the problem solving, and the hands-on techniques—those must happen in our classrooms. They must provide a hands-on experience to kids. You will see a videotape that goes through this cityscape project that we created and see how that came together.

Now we also looked at the fact our kids needed to walk away with certain skills, certain tools. The MacIntosh computer was an excellent tool to put in the classroom, but it's kind of like this pencil. Now there are certain things that I can do with this pencil, and certain things that I can't. Although this computer—we didn't have any educational-assisted instructional software to use. What did we have? Well, we looked around and we found what we call productivity software. There was word processors. What are word processors useful for? Communicating ideas, preparing written reports.

We found that kids could now manipulate text in the computer, rewrite and perfect those papers, and they ended up making those changes 8 to 12 times. I'd give a kid a pencil and say, "Write me a paper," how many times do you think that paper gets revised? One. And the student who may rewrite it one time is the exceptional student. Put them on a computer and all of a sudden they can rewrite any number of times. It's a matter of moving pieces that don't fit or reorganizing your thoughts, and the keyword there is the student's thoughts.

What else could we use? Well, we use data bases. Data bases allow us to sort, to analyze, to rearrange, and make decisions about material. I created a data base that my students used on the Periodic Table, and all of a sudden they were able to see relationships that didn't come off of that table. They were able to see that elements in a certain column, certain family on the periodic table had some similarities. And the computer easily manipulated that stuff so it became real apparent to the kids, but the kids did the manipulation.

We needed a way to calculate rapidly. In a typical math class, we assign the kid 500 problems and we want that back the next day. That's a repetitive kind of thing and it may not have a lot of major impact. But, if you teach the kids how to do the math and what's important, and then give them a tool that does that for them quickly and accurately, we found that kids learnt those formulas that science is always trying to stress that they learn. Kids manipulated those formulas, and you'll see my students demonstrate that with a spread sheet. Remember a spread sheet is a calculating/accounting package for business. We used it in a slightly different way.

That spread sheet also allowed us to create graphs, and from those graphs the kids not only understood a concept—for example, acceleration—but they had a graph that helped explain. A picture is worth a thousand words, and that is in a sense what happened.

But we went one step more. Apple came up with a piece of software called HyperCard, and I've heard HyperCard referred to as a great many things. Probably the best explanation is that it's an erector set that allows you to build your information in any manner you choose to build it. In HyperCard, my kids can animate these manipulatives. They have the model now that works.

In the process of trying to explain DNA to my biology students, the old precomputer, pre-ACOT method took about three weeks. In ACOT, I started the first day, I gave the kids the pieces that were going to go into this model for them to play with, and the second day they were explaining to me how DNA is transcribed and turned into a protein molecule.

So, by using the models, the kinds of things we've done in science, if we can facilitate that with a fancy computer, a high-tech piece of equipment, a lot more comes out of it.

High school labs are poorly equipped. Microscopes at best will read a newspaper, and that's not a very good piece of equipment to have in a lab. You know, electron microscopes are being used in the research area. Can we bring those into a classroom cheaply? No. But what we can bring in is something called a laser video player, and on that player is still pictures, sometimes animated pictures, of real life images that kids can manipulate that image.

Movies and videotape have played a big role in education, but there is a major problem with those. The average tape that—tape or movie that gets checked out of a library by teachers is 30 minutes long, and every good teacher shows it from beginning to end, even though there is only 30 seconds worth of material in the middle. The other problem is that when I checked that movie out on Monday and three students were absent, they totally missed it. Now, my bias is, if it was important enough for me to show to my students, it should be available so I can show it to them all of the time, any time I choose to do that. The video player is in my classroom and the students can go to it. They have to make the decision. When we were talking about insects, Sadi had to decide what's the best example to show you. When we are talking about arachnids, Mittie had to decide what's the best things to show you, and that was a decision she made. She became the expert on arachnids, Sadi became the expert on insects, and they taught those concepts to the rest of the class.

Now it wasn't me doing it. My role in that class was to make sure the right videodisc was available to Sadi and Mittie when they were talking, make sure they had this piece of equipment and that, and I allowed them to do it.

We have a computer network in the classroom that facilitates the sharing of ideas. Students work together. You know, there was a fear that computers would isolate kids. I have observed kids plug two keyboards into the same computer, share when they typed so that the information didn't get jambled around, jumbled around, and worked collectively in terms of creating a project. A lot of input.

Collective learning seems to be a very neat way to go. Real life situations are collective. Very few people ever work on a project all by themselves. My students observed me working collectively with a major group of people to prepare this testimony. First, I involved them by asking them, What should I say to Congress? The first thing they said—they said two things—was that, number one, we're a family going through a learning process here in which person has an equal respected role. My opinions are important in that class. My input in that class is important, and I can talk to anybody in that class and get help for what I'm doing.

The second thing they said was that the skills in this class prepare me for the 21st century. Have we witnessed that? Yes. Businesses have come to us and said, Could we possibly hire some of your students to teach our employees how to use spread sheets, word processing, data base, page layout, et cetera? We had colleges come to us and say, You know, this computer seems to be a great tool for writing but at the college level we don't have any kids who know how to use computers, and we're putting this in as a writing tool. Could we possibly hire your high school students to be teaching assistants in our college writing labs? And we're saying, yes, that sounds like a good idea. But could you give our kids free tuition to your college? In other words, there's going to be some tradeoffs here.

[Laughter.]

So our students are becoming involved in the business community, and business is finding that our students do a much better job explaining. Because what have our students done? We've given them a computer. The computer is very easy to use. There're some intuitive things about the MacIntosh. One of the things about the MacIntosh is that almost all software has a commonality. This was forced into the development by Apple. So when our students learn one piece of software it transfers to another.

Now, we teachers have a big job to do in education, and one of the things that has happened to us is that we've changed our outlook to the classroom. We've had visitors come through this classroom and say, "Well, who's teaching this class?" or "What's going on in this class?" I'm not standing up in front lecturing for 45 minutes. I'm standing there talking to a visitor on that day, and I'm saying, "Well, the kids are doing this project in biology and they're going through the information the same way they have observed me doing it." My students have followed a role model that was set up in that class. That was my job: providing them with the assignments, showing them what it was I could do.

There was a certain risk when we started this. One of the risks was we didn't know how to use this computer, and we didn't know if there was anything out there we could use with it. We had to find ways to use it. We had to solve that problem.

Another risk that we have taken is we allowed our student to take part in their learning. And that sometimes sounds like a very risky thing to do. Our students became the focus of the classroom. Who was there to learn the most? And we made the assumption that those who are here to learn the most are the ones who should be doing the most in our classroom. I've already gotten a degree in biology, so, obviously, I know something about biology. So should I be the one who spends the most time doing something in my classroom? No.

One of the things I've found happen in a simple dissection lab was the young lady who had developed the unit kind of asked me to step aside and get out of her way and let her explain all the stuff to the class. What better teacher was there in that class than that person who had worked through the process?

Okay. Teachers have to be learners in the classroom. They have to model learning. We know that a great man once said that coaches need to learn to teach and teachers need to learn to coach, and I heard that coaching analogy used here a while ago. The teachers coach the students, show how learning takes place, shows students how to solve problems, much more learning takes place. And a very simple example of that is, if a kid asks me how to spell a word and I spell it for him, the kid didn't have to learn the process of finding out the spelling of a word. But, if I hand the kid a dictionary or show the kid that I go to a dictionary when I have trouble spelling a word, the kid will start going to the dictionary. The same thing applies in all classrooms.

In my classroom there are often situations where there are 30 teachers and one student, and that student is me. And my students say, no, this is the way it really should be done. Since I entered this classroom I have to now some times shut up and listen to what they're saying, and they're usually right. You know, I entered a situation that I knew very little about; I did have some computer background. But my students became the teachers in that classroom. They also realized that certain students learn how to do math at a faster rate than others, certain students are better at writing, certain students are better at art, social studies, science, and they align themselves with experts when they do a project.

Okay. At this point I'd like to thank you for this opportunity. My students and I would like to demonstrate some things to you, and we would invite your questions at that time. I'd also like to point out that there are some colleagues here from an ACOT site in Nashville, an ACOT site in Tucson, that are also going to demonstrate some things. The thing I also want to point out there is that the students are going to be showing you how we do education, not the teachers.

Thank you.

[The prepared statement of Mr. Stebbins follows:]

Testimony

By

Barry Stebbins
Teacher
Apple Classroom of Tomorrow (ACOT)
West High School, Columbus, Ohio

On
Science and Mathematics Education

Before
The U.S. House of Representatives
Committee on Science, Space, and Technology

June 7, 1989

The Problem: Schools Are Not Preparing Children To Learn and Work in the 21st Century

It's not news that the rising school dropout rate, diminishing academic skills, and criticism by parents, educators, and business leaders are signs that public school education desperately needs reform. Tactics such as the Back-to-Basics movement and the use of technology to "mechanize" traditional curriculum and instruction do not work. These approaches maintain an Industrial Age model of education that is static and irrelevant in the Information Age. Our society produces information and changes so rapidly it is crucial for young people to become independent learners and critical thinkers in order to be responsible contributors in the 21st century.

At West High School in Columbus, Ohio, there is a community of students and teachers that has developed educational approaches that *do* promote independent learning and critical thinking. In addition, the ninety students involved in this Apple Classrooms of Tomorrow (ACOT) research program have managed to reverse the dismal trend in education. Columbus ACOT students maintain a 0% school dropout rate compared to 25% nationally. And their increased ability to collect and analyze information, solve problems, and communicate across all academic subject areas *does* prepare them for today and tomorrow.

ACOT provides teachers and students with immediate access to computer technologies and encourages them to develop instructional models that empower students to construct their own knowledge. Students are randomly selected to participate in ACOT and then placed in the college preparatory program even though many of them would not have chosen this path. Even students with below grade-level basic skills have succeeded in these advanced classes. We believe this is due to their exposure to a project-based, interdisciplinary approach to learning that is supported by computer technology.

The Solution: An ACOT "Community of Learners"

When the ACOT program first began at West High School we were concerned that the computer placed on each student's desk would cause less interaction among students. Instead, we found the opposite. Computers turned out to be a catalyst that encouraged productive interaction among children. Because we believed that students should be part of the instructional team, we encouraged them to share their expertise with their fellow classmates. In fact, what happened was that the students frequently taught the teachers how to use various software programs in ways that the teachers hadn't yet discovered. Since then, we have all become learners. In fact, we have created a partnership in learning. Ours is a community that is composed of life-long learners who find innovative ways to solve problems in cooperative ways. We call it the Community of Learners.

A team-teaching approach supports project-based, collaborative learning across all subject areas

In a typical high school, each subject area is treated as a separate entity. This causes students to regard English classes as having no connection to science, mathematics, or social studies. In reality, however, all subject areas are connected in many ways and should be presented to students as interdependent. Collecting and analyzing data to produce useful information are important skills in all subject areas, so there certainly should be coordination of these subjects to show students how the skills fit together.

At West High School, ninth- through eleventh-grade students in the ACOT program learn basic math and science concepts through an individualized, interdisciplinary approach. The merging of math and science helps students develop a greater understanding of the concepts taught in both areas. Through team teaching, the understanding of concepts from both subject areas is put to use in the development of models that help explain the real world. Students use spreadsheets, databases, and animated demonstrations to build their own models cooperatively with their peers.

For example, in order for science teachers to teach Newton's Laws, students have to understand underlying algebraic concepts. Typically, algebraic formulas are taught and memorized in math class and students are unable to transfer the concepts to science. However, the ACOT science and math team teachers have been able to satisfy science curricular needs and reinforce algebraic concepts at the same time. We employ several tools to do this important task. First, we have students use their computers to set up a spreadsheet with a three-variable equation that describes one of Newton's Laws. Second, as we discuss the mathematical operations, students rearrange this equation into alternative forms. Third, students perform a science experiment and put the data they collect into the spreadsheet to analyze their results. Fourth, students use the graphing capability in the spreadsheet software to create a "picture" that helps them further understand the science and math concepts. Finally, they use Apple's HyperCard software to create an animation sequence that explains how any equation can be rearranged into equivalent forms.

The major goal here is to help students understand the mathematical concepts that underlie the equations by having them rearrange the equations. The computer can not do this for the student, but the computer can rapidly calculate the answers to any equation students enter into their spreadsheets. As a result, students realize that the computer will do the calculations for them, but this is only useful if they enter the correct equations. In addition, team teaching with computers allows students to combine concepts in science and math, making them real and meaningful.

Team teaching and integration of subject areas does not stop with math and science at the Columbus ACOT. The students' entire basic program is integrated as well. During a five-period block of time, students learn math, science, English, and social studies. In addition, they have a study period with their ACOT teachers. We find that this holistic approach to learning further promotes close student-student and teacher–student relationships in our community of learners. An emphasis on cooperative learning, sharing ideas, and respect for individual talents, permits learning to extend beyond the basic goal of the project, reaching the needs of the individual as well as the entire group.

Technology tools empower students to construct their own knowledge

The ACOT program at West High uses the Apple Macintosh computer and a wide variety of productivity software as its basic tools for teaching and learning. Through the use of word processing, database, spreadsheet, art and graphic design, page layout, robotics, HyperCard, and videodisc technology, the educational objectives are not only being met, but extended. Student projects, supported by these software packages, provide an action-oriented environment in which learners gain experience in practical and conceptual problem solving.

Students also learn to select appropriate software tools to fit the needs of their projects. And by using software that is predominant in business they gain experience with professional tools. In fact, our students are already working in classroom environments that closely resemble professional working environments that are project-based, collaborative, technology-supported, and provide spontaneous feedback and evaluation from colleagues. Consequently, as the students work on various projects, they gain an understanding of how the real world functions.

We are most fortunate to have picked the Macintosh computer for our project. When we first started, we were somewhat reluctant because we didn't have the wide variety of instructional software that's available for the Apple II family of computers most commonly used for education. Software vendors simply were not creating instructional software for what many perceived as a business only computer. So our first task was to find ways to integrate database, spreadsheet, word processing, and other productivity software into our classrooms.

In science and social studies, database software seemed like a natural tool. It allowed us to analyze, sort and arrange various pieces of information. This fit into our goal for students to use information to form conclusions. In science and math, the spreadsheet seemed like a great tool to analyze data and do rapid calculations. It also helped us teach concepts such as algebraic manipulation of equations. Word processing was the obvious tool for communicating ideas in all subject areas because it enabled students to revise, rethink, and restructure their thoughts quickly and easily. Graphic design and page layout software permitted our students to expand their ideas into sophisticated presentation formats. Not only were our students able to improve their written communications, they also began to explore ideas visually without having to settle for words that didn't express their thoughts as precisely.

Finally, HyperCard software has enabled our students in teaching roles to animate concepts and make them come alive to other learners. Not only does it allow students to manipulate text and visuals, it also brings a new dimension to their presentations. By using animation techniques students can now design graphics that enable them to explain concepts more effectively. Problem-solving skills are further enhanced as students search for even better ways to explain and manipulate ideas. And when students learn HyperTalk programming language to design HyperCard projects, they learn to process ideas in logical sequences. They also have to work through the design process in a more thoughtful manner since as teachers, their audience is a major consideration.

One of our most important technology tools is our local area network. By linking together classroom computers we are able to share information much more effectively. We believe that publication of student work in all subject areas is an extremely important incentive for high quality thinking and production. The network provides such opportunities. For example, student working groups can store research notes and report drafts on the network, enabling all members to contribute to and revise the materials. The network also saves time and effort. It reduces the number of trips to the copy machine and cuts down on the amount of paper handling. Instead of making multiple copies of a handout, teachers and students can simply place it on the network. For instance, I can use the network to "pass out" an assignment on DNA molecules. Students then "receive" the assignment at their own computers and complete the work. When finished, they either save it on the network or print it on one of several networked printers.

The availability of other computer-based technologies such as interactive video have also strengthened our learning community by enabling us to observe complex concepts and experiences that are difficult to understand. In biology, for example, students can now see "live" videos of microscopic specimens close-up. Before this technology was available, they might have been able to observe these examples under a microscope, but the view was less clear and it took much more time. Because the video component can be controlled by HyperCard software, students can design and produce their own insightful presentations. With this technology readily available in the classroom, students use it independently to review the material or view it for the first time if they missed the presentation.

Projects provide a context in which students construct their own knowledge

The ACOT teaching team works together to link all subjects and invent creative ways to help students construct their own knowledge. Last year, for example, we developed a robotics unit for the computer applications class that expanded into a major project involving all subjects. The goal we set and ultimately accomplished was to build a scaled model of downtown Columbus, complete with computer-controlled elevators, traffic lights, and other automated devices.

To accomplish this, students first learned to use the software that enabled them to build and control robotic models. Next, they researched, designed, and built scale models of actual buildings in the downtown area. This was followed by documenting the history and telling the story of how the old city has developed. The project drew upon skills and concepts students had learned from various curriculum areas—electronics from science, proportion scaling from mathematics, research from social studies, writing from English, and design and construction skills from art.

As the project developed, students' problem-solving skills were pushed to new limits. In one case, students had to depend on trial and error methods to assemble a robot from a kit that provided inadequate directions. When the solution was not readily apparent, lively discussion among classmates ensued as they searched for a way to solve their problem. On another occasion, students had to call upon their problem-solving skills to find the exact proportions required to construct scale models of the buildings. As the problems of assembling each building were solved, the underlying mathematical concepts became far more meaningful than isolated textbook problems. In addition to applying mathematical principles, this project took on real meaning for the students because they could relate to how adults work.

Teachers in this Community of Learners place students at the center of their own learning

The "right" teacher for this environment is constantly looking for ways to empower students. This is also a risk because when empowered, students pursue areas of interest and they often become more knowledgeable than the teacher. The teachers' role involves guiding learners to take on increasingly greater challenges. It encourages them to go beyond the required assignments and raise other points of view, even when they differ from accepted theories. This teacher also realizes that he or she is not the only source of information in the classroom. Other students, teachers, technology tools, and the whole world can provide valuable resources for learning.

It takes a special kind of teacher to be an active partner in this community of learners. The teacher must be someone who looks for innovative ways to present lessons, who is not afraid to take risks, and who will try out new technologies even when it may not be immediately apparent how these technologies can be used. In this community the teacher is most certainly a learner and shares that experience with the students.

Barry Stebbins
Biographical Sketch

Mr. Stebbins graduated from Ohio State University in 1971 with a degree in Science Education. Although he was certified to teach every science course offered in the Columbus schools, he began teaching General Science at Roosevelt Junior High on the city's south side. In 1979 Barry moved to Wedgewood Junior High where he taught the Occupational Work Adjustment (OWA) program for dropout-prone students. A year later he continued teaching the OWA program at West High School. During his time with the OWA program Barry became interested in computers and began using them in the classroom to increase student productivity and performance. Through this experience he observed that students did four- to five-times more work when they used computers.

In 1986 Barry helped launch the ACOT program at West High School. Since then, his teaching approach, curriculum materials, and relationships with students and colleagues have changed dramatically.

In Mr. Stebbins' classes, students are now active rather than passive learners. They build curriculums, take on teaching roles, and participate in team projects. With technology readily available students can learn by building realistic simulations and animations that illustrate the concepts they are studying. Using this collaborative approach to teaching and learning, supported by computer technology, Barry's students are actually constructing their own knowledge.

The work that Mr. Stebbins has accomplished with ACOT students at West High has earned him considerable recognition. Not only has he presented at numerous state and national conferences, he has also won the Lazarus Writing Award for authoring "Using HyperCard in the Apple Classroom of Tomorrow," and the Sigma X Outstanding Science Teacher Award.

The Apple Classroom of Tomorrow ACOT

A Project of the Advanced Development Group

ACOT Science and Math Programs That Work
Demonstration Overview

It's not news that the rising school dropout rate, diminishing academic performance, and criticism by parents, educators, and business leaders are signs that public school education desperately needs reform. Tactics such as the Back-to-Basics movement and the use of technology to "mechanize" the traditional curriculum do not work. These approaches maintain an Industrial Age model of education that is static and irrelevant in the Information Age. Our society produces information and changes so rapidly it is crucial for young people to become independent learners and critical thinkers in order to be responsible contributors in the 21st century.

The Apple Classrooms of Tomorrow™(ACOT™) research program has managed to reverse the dismal trend in education within its classroom sites. ACOT students maintain a 0% school dropout rate compared to 25% nationally. And their increased ability to collect and analyze information, solve problems, and communicate across academic subject areas *does* prepare them for today and tomorrow.

The ACOT program of research examines how the educational process changes when students and teachers have immediate access to computers and other interactive technologies. Besides providing the technology, ACOT helps teachers develop instructional models that empower students to construct their own knowledge. Teams of researchers, educators, students, and software developers combine talents to create interactive learning tools and curriculum approaches that are integrated into ACOT and other classrooms. ACOT demonstrates in real classrooms that when teachers have the appropriate technology tools, they can more effectively help students become motivated, independent learners and competent, critical thinkers.

The ACOT science/math projects that you see demonstrated today represent the kinds of educational partnerships supported by the Apple Classrooms of Tomorrow research program of Apple Computer, Inc.

Elementary School

The ACOT team from Dodson School in Nashville, Tennessee, demonstrates how fourth graders can learn science and math concepts by constructing models of cars, cranes, houses, robots, and other devices. In collaborative working groups, students plan their projects, organize the labor force, build the models, and present the completed projects using Lego construction kits and Logo software. These LegoLogo materials allow students to program and control their models using motors, lights, and switches.

LegoLogo materials help put complex scientific and mathematical concepts into action in practical concrete projects that are, in many ways, analogous to projects in science and industry. In the ACOT classroom, LegoLogo activities are part of an integrated program of problem solving in science and mathematics. Students work individually and in teams applying basic and advanced concepts in these construction projects. The projects provide them with an action-oriented, hands-on environment to gain experience in practical and conceptual problem solving. The students make mistakes in the process of construction, rethink their assumptions, and try new approaches, until they find solutions that work.

Middle School/Junior High

The group from Orange Grove Junior High School in Tucson, Arizona, demonstrates how computer simulations enable learners to create and explore imaginary worlds that behave like the natural world, but permit scientific experimentation that would be too expensive, dangerous, or otherwise impossible to experience in reality.

Using simulation software, the students build a model of a state park. They are free to design any kind of park within a given budget and certain parameters such as maintaining the natural terrain. The simulated model enables them to build parking lots, picnic areas, hotels, or boat launches and observe what the impact will be on the environment. In the process they learn what they can afford, what pollutes, and what causes overcrowding. Ultimately, the goal is for students to understand integrated systems—their structures and the interrelationships between those structures. In this case, the structures include ecosystems, environmental policies and politics, land use, and population dynamics. The students learn these concepts by thinking, hypothesizing, and modifying components, not merely by listening and writing.

High School

The group from West High School in Columbus, Ohio, demonstrates how students use multimedia tools (that combine sound, visuals, and text under computer control) to explore science and math, construct their own knowledge, and share the results with others. For example, students create interactive video biology lessons that they then use to teach the concepts to classmates. One such unit presents arthropods, complete with pictures, text explanations, and video clips that demonstrate particular concepts. When explaining the reproductive process of spiders, for instance, it seems that the female is likely to assume the male is food unless he gives some rather clear clues. A video clip in the interactive lesson shows just how the male spider makes his identity known to his potential mate. Because these students play such an active role in their own learning, they are more motivated and more willing to take on new challenges than their peers in traditional classrooms.

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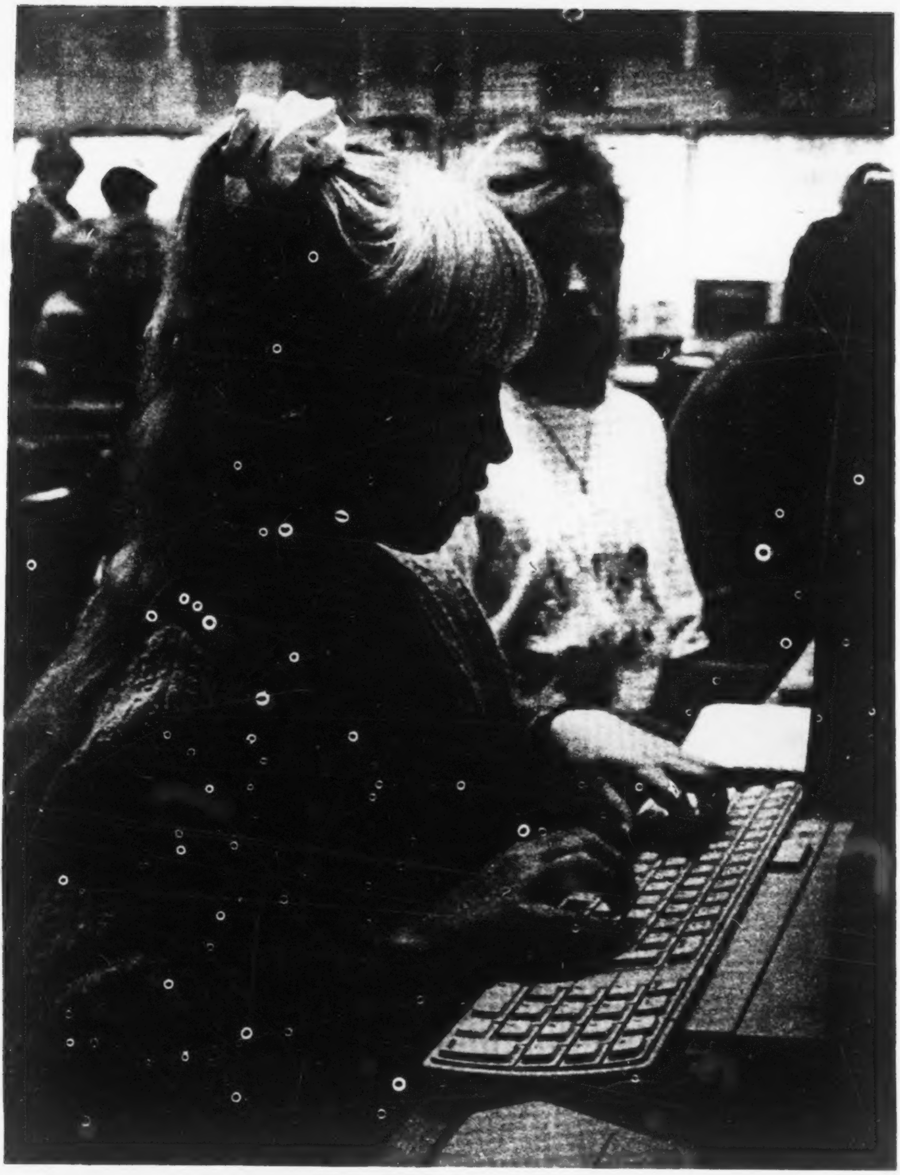
ACOT
Apple Classroom of Tomorrow



ACOT
Apple Classroom of Tomorrow

OVERVIEW..........................3

RESEARCH..........................7

DEVELOPMENT..............11

TEACHERS........................15

CLASSROOMS.................19

The Apple Classroom of Tomorrow is a project of the Advanced Technology Group, Apple Computer, Inc.

OVERVIEW

Educational change is imperative to prepare children for tomorrow.

Educators, parents, business leaders, and policymakers are calling for major reforms in education. They believe that in a society that generates knowledge and develops technologies as rapidly as ours does, it is crucial for individuals to learn to cope with change and uncertainty. Schools must create entirely new approaches to learning in order to prepare children for a future in which problem solving and lifelong learning are fundamental.

Technology has already played a part in changing many sectors of our society, but so far, it has had little impact on education. Can technology be used to bring about positive changes in teaching and learning?

ACOT℠ research shows that dedicated teachers can use technology to provide new learning opportunities for their students with a variety of positive outcomes. However, the same research also shows that technology alone will not bring about fundamental change in curriculum and instruction. Continued research and development are essential.

ACOT seeks to advance educational change by promoting effective uses of technology. The project does this by supporting both teacher innovations and long-term research and development projects.

What Is ACOT?

ACOT is a research project and an active agent of change.

The Apple Classroom of Tomorrow℠(ACOT) is a research project that explores learning when children and teachers have access to interactive technologies.

ACOT is also an agent of change that seeks to influence educational reform by implementing goals that set a process in motion.

Project Goals and Process

- Create innovative learning environments that take full advantage of technology
- Study how these environments affect teaching and learning
- Share the results with stakeholders in educational change and use the results to re-create the vision

What Does ACOT Do?

ACOT explores new learning environments by establishing classroom sites with high computer access, encouraging teacher innovations, and sponsoring a variety of research projects.

Establishes Classroom Sites with High Computer Access

ACOT explores new opportunities for learning by providing classroom teachers and students with ready access to technology at school and at home. Because ACOT does not believe there is one best way to use computers for learning, the project supports different models and offers teachers opportunities to create their own unique learning environments.

Supports Teacher Innovations

Constant access to computers provides ACOT teachers with the opportunity to acquire technical skills and explore new uses of technology in all aspects of their teaching. This experience tends to promote the process of thinking with technology such that it becomes a natural extension of their hands and minds. When this happens, ACOT teachers begin to think and act differently about their work. They dream up new curriculums and teaching techniques that take full advantage of technology.

The challenge for ACOT—to support teachers and encourage them to move forward—is met by expanding their knowledge of current learning theories and exposing them to new curriculum ideas. As teachers envision new instructional ideas that use technology, the project provides them with the training, consultants, and equipment that allow their ideas to be implemented and evaluated.

Sponsors R&D Projects

ACOT also advances positive change by sponsoring a number of curriculum development projects. These projects address common problems in learning that have been identified by research, such as the difficulty that some students have with organizing their writing logically and coherently, and the difficulty that others have with solving problems in abstract domains such as math and physics.

Maintains a Program of Long-Term Research

In order to understand how technology can best support teaching and learning, the project funds university-based researchers to study the ACOT classrooms. Currently a dozen studies are under way, examining important questions that will take a number of years to answer fully. Research questions include the following: How does high access to technology affect curriculum and instruction? How can computers be used to empower students to take responsibility for learning? How are computers used in students' homes? How do students organize and use information when they have constant access to computers?

Develops New Research Tools

ACOT promotes change in research procedures by applying new tools for collecting, analyzing, and interpreting data. These tools include the use of hand-held computers for collecting data; new database systems for managing and analyzing numerical, textual, and multimedia data; and new tools for visualizing data.

Who Is ACOT?

ACOT is a network of people who create and study innovative learning environments and implement educational change.

The Apple Classroom of Tomorrow is a flexible network of researchers, educators, students, and parents who work collaboratively to create and study innovative learning environments and implement educational change. The project is funded by Apple Computer, Inc. and orchestrated by the ACOT staff, within the Advanced Technology Group at Apple. The staff includes:

- **David Dwyer,** Project Manager and Principal Investigator
- **Wayne Grant,** Curriculum Development and New Technology Research Manager
- **Keith Yocam,** Site and Teacher Development Manager
- **Linda Knapp,** Senior Writer
- **Jacqui Giddings,** Developer and Site Support Specialist
- **Loree Taylor,** Coordinator
- **Connie Troy,** Area Associate

For further information, contact Connie Troy, Apple Computer, Inc., 20525 Mariani Avenue, M/S 42C, Cupertino, CA 95014; (408) 974-5219.

RESEARCH

ACOT believes that high computer access will be common in schools of tomorrow, and therefore, it is critical to understand how technology can and cannot be used to maximize learning.

Research projects supported by ACOT are exploratory efforts, centered in classrooms that are also dynamic research environments.

The Apple Classroom of Tomorrow project is committed to developing a program of long-term research on the impact of technology on teaching and learning. Based on the assumption that high computer access will be a common feature in schools of tomorrow, we believe it is imperative to understand how technology can best be used in learning environments today.

Our approach has been to develop high access to technology in schools and homes, to support teachers through training, and to conduct studies in these learning contexts. The national Office of Technology Assessment (OTA) strongly echoes this strategy. In fact, their 1988 report advises that if policymakers want to realize the potential technology holds for education, they must support programs that share these characteristics. ACOT also shares the OTA position that there is no single "best use" of technology in schools. That notion is the foundation for our support of individual site goals and our encouragement to develop different models of computer use.

The research studies sponsored by ACOT assess these models over time, addressing such issues as whether technology can help students become independent learners, whether it can help learners solve complex problems more effectively, and whether it can enhance students' sense of efficacy. Developing these kinds of perspectives means commitment to a long-term, multifaceted research program.

ACOT research projects tend to be exploratory and centered in schools. Projects are modified continually by the research teams as they progress and as the learning environments change. Teachers, students, and researchers work collaboratively in the definition and conduct of these studies. Teachers, for example, note changes in their students and/or themselves that they attribute to technology, such as increased self-esteem, motivation, and productivity. Researchers then examine these hunches by applying qualitative and quantitative techniques. These and other research findings become the foundation for developing better-informed innovations, as well as new studies. The process is cyclic, with continual forward movement toward the thoughtful application of technology to the greater goal of helping children learn.

The following descriptions of projects-in-progress represent the scope of the ACOT long-term research agenda. A complete project list and selected summaries of individual projects are available through ACOT. Original research documents are disseminated through the ERIC reproduction system.

Assessing the Effects of High Computer Access on Teachers, Students, and Families

The assessment study is a long-term effort to explore and evaluate the effects of HCA on students, teachers, and families.

In this multiyear study, researchers from the University of California at Los Angeles (UCLA) assess the effects of high computer access (HCA) on ACOT students, teachers, and families. To do this, the research team is developing assessment techniques that are sensitive to the changes that may occur in HCA classrooms and homes.

Currently, team members are analyzing achievement data and collecting information on student and teacher attitudes toward self, learning, and technology. They are also exploring nontraditional outcomes attributed to HCA, such as student productivity and problem-solving ability. When appropriate measures do not exist to assess nontraditional outcomes, the researchers develop them.

Student Thinking Processes in a High Computer Access Environment

The study of student thinking processes examines how HCA influences the development of thinking skills.

In this longitudinal study, the research team examines the relationships between the computer, writing, thought, and learning in order to explore how high computer access supports the development of thinking skills.

The research process includes the following steps: (1) observing students' writing behavior to gain insight on their thinking processes, (2) conducting daily interviews with students to probe the nature of their thinking while writing, (3) conducting general interviews with students to obtain perspective on their use of the computer at school and at home, and (4) applying measures across time to document student development. The data, in the form of videotaped observations, record sheets, and tape-recorded interviews, are logged, transcribed, coded, and analyzed.

The Experience of Teachers in a High Computer Access Environment

The study of ACOT teachers examines the experiences they undergo when facing the challenge of helping children learn in an HCA environment.

This exploratory study examines the experiences that ACOT teachers undergo when they move into high-technology learning environments. To enter this arena as a computer novice, responsible for the education of many learners, is a challenge to say the least. Yet this is exactly the situation faced by most ACOT teachers when they join the project. The study addresses such questions as: How does the experience affect their lives? How do their teaching perspectives and behaviors change? How do they perceive changes in their students?

The data are gathered from weekly written and audiotaped reports by teachers that document their personal experiences, as well as videotaped interviews conducted periodically during the life of the project. The study involves the experimental use of a sophisticated relational database for the retrieval and analysis of qualitative data.

Classroom Process and Student Experience

The classroom process study compares ACOT classrooms with more traditional classrooms and explores the potential for learning in an HCA environment.

In this study, researchers compare the ACOT high computer access classrooms to more traditional classroom environments. Teachers and visitors report that teaching and learning in ACOT classrooms are dramatically different from what they have observed in traditional classrooms, yet further analysis reveals striking similarities. The study seeks to identify what is the same, what is different, and why, and to determine the implications for teaching and learning in HCA classrooms.

To address these questions, ACOT is developing innovative research tools for gathering dynamic "pictures" of life and changes in HCA classrooms over time. Anthropologists and educational ethnographers, working through UCLA, will have the opportunity to study these data and to follow up with more detailed studies of individual student experiences in the program.

DEVELOPMENT

The ACOT research and development program directly translates research findings into curriculums, tools, and learning environments that can ultimately be integrated into other classrooms.

In addition to the project's commitment to long-term research, ACOT is also building a program of applied research and development. The R&D projects directly translate current research findings into curriculums, tools, and learning environments that can later be integrated into ACOT and other classrooms with advanced technology. By introducing teachers to new curriculums and learning environments that work, the ACOT R&D program encourages them to break away from traditional methods of instruction.

ACOT is not alone in this position. The national Office of Technology Assessment states in its 1988 report that teachers need to be exposed to and be part of breakthroughs in education, and that researchers need greater exposure to classroom realities. The OTA also suggests that technology-based innovations that support current research on learning—such as intelligent tutoring systems, simulations, multimedia systems, and new assessment techniques—need further research and development if their potential is to be realized. ACOT shares these objectives, and, after a year of program building, there are already a number of projects under way.

ACOT R&D projects generally involve university-based researchers working with K–12 teachers to address particular areas of learning that are often difficult for students. The research teams then propose solutions that involve developing technology tools and curriculums to help students overcome their difficulties and become more effective learners.

The following descriptions of current R&D projects represent the range of ACOT research and development efforts. A complete project list and summaries of work-in-progress are periodically available through ACOT.

Exploring the Use of Interactive Audio and Visual Media to Improve Student Writing

The Berkeley project explores the use of audio and visual materials to help "at risk" students learn to organize and express their thoughts clearly in print and other media.

Researchers from the University of California at Berkeley are working with high school and college teachers to explore the use of audio and visual materials to help "at risk" students organize their thoughts and express them clearly in print and other media. They hypothesize that students' natural interest in visual and audio media will enable them to organize and present information more easily in these media. This skill will serve as a bridge, helping students organize and express their ideas in print.

The R&D team is creating two kinds of multimedia database tools for students. One contains blocks of audio and visual information that students can link together to build convincing and powerful essays. The other contains experts' reflections on how they go about composing; these descriptions provide inexperienced writers with a variety of models from which to choose.

Developing a High School Physics Curriculum with an Intelligent Tutoring System

The NASA project aims to help students develop more effective strategies for solving physics problems by using an intelligent tutoring system.

In this project, researchers from the University of Houston, NASA/Johnson Space Center, and the Texas Learning Technology Group are working with a high school physics teacher to help students develop more effective strategies for solving physics problems. The R&D team is developing a computer-based physics curriculum with an intelligent tutoring system (ITS) that can pinpoint students' difficulties and provide feedback and coaching as they progress through the curriculum.

Ultimately, the physics curriculum with ITS will work like this: While students work through specific lessons, the computer tutor will develop models that describe their approach to related problems. Once the tutor identifies students' particular misunderstandings or difficulties, it will coach them to apply more effective strategies for solving those kinds of problems.

Developing Technology Tools to Display and Analyze Qualitative Research Data

The Cornell project seeks to develop more appropriate tools for collecting, managing, analyzing, and displaying qualitative research data.

This project involves an R&D team from Cornell University in the development of more appropriate tools for collecting, managing, analyzing, and displaying qualitative research data.

Team members are first exploring how computers can assist in the process of dealing with qualitative data. Then they will initiate a long-term effort to design and develop software tools that are appropriate for conducting qualitative research. One tool, for example, will be a database of graphical displays and techniques that can be used in qualitative analysis. With this database and Apple's HyperCard® software, the team will develop prototype analysis software that combines a variety of qualitative data.

Exploring the Use of Hypermedia to Help Learning-Handicapped Children Improve Problem-Solving Skills

The Vanderbilt project explores the use of hypermedia tools to help learning-handicapped children acquire basic math skills and a conceptual knowledge that enables them to solve real-world math problems.

Researchers from Vanderbilt University in Nashville, Tennessee, are working with an ACOT special education teacher to help handicapped children acquire basic math skills, and then link these skills to a conceptual knowledge of mathematics that will help them solve real-world problems.

To do this, the R&D team is developing an instructional approach that uses software (developed by Vanderbilt) and hypermedia tools. The instructional approach includes three steps: First students master certain basic skills using the software; then they watch video segments that depict individuals using those skills to solve realistic problems; and finally, they work with HyperCard stacks that present problems for them to solve using the skills they have learned.

TEACHERS

ACOT teachers have become leaders in the advancement of educational change.

ACOT teachers are at once ordinary and extraordinary. Ordinary, because they represent a typical cross section of American public school teachers. Extraordinary, because they teach in classrooms that simulate future learning environments, and because they have become leaders in the advancement of educational change. In these high-tech classrooms, ACOT teachers are now initiating so many innovations that they are frequently called upon to share their expertise with educators and policymakers at state and national levels.

The Evolution of ACOT Teachers' Expertise

At first, ACOT teachers used technology to mechanize the curriculum.

Over time, they have begun to apply research findings and implement new curriculums and instructional methods that foster independent learning and critical thinking.

The professional growth of ACOT teachers since the project began has been remarkable. Three years ago, when teachers started working in classrooms that featured a computer for every student, they typically relied on familiar, teacher-directed instruction, and they used technology to mechanize the existing curriculum.

Before long, however, they noticed that students were beginning to use the computers to explore new territory, beyond the textbook and the standard curriculum objectives. Often students would pursue individual interests, extending their learning past the teacher's expertise. This emerging power of students to learn independently and bring new knowledge and tough questions into class discussions was disconcerting for many teachers—not because the students were powerful learners, but because the teachers didn't know how to guide them in using the technology to expand their learning.

Over time, ACOT teachers have begun to find ways to foster students' identity as empowered, independent learners, and to enhance their own role as managers and facilitators of learning. Teachers have begun to modify and invent new curriculums that invite students to search for information from a variety of sources, organize it, and analyze it, rather than simply memorize information from a textbook. Teachers are also beginning to play an active role in the ACOT research agenda, and with research findings to guide them, they are becoming powerful agents of change.

However, changing the structure of education is not easy. ACOT teachers need solid support from the project as well as their own school administrators in order to develop new curriculums and teaching methods that are worth promoting.

ACOT Teacher Support

ACOT support focuses on increasing teachers' knowledge of research theories on teaching and learning, expanding their technical expertise, and encouraging them to share acquired knowledge and skills.

ACOT believes that all teachers should have support and encouragement to expand their expertise and take on leadership roles. They must be free to attend conferences, explore new educational tools, try out alternative models of instruction, and create innovative curriculums.

ACOT support focuses on increasing teachers' knowledge of research theories on teaching and learning, expanding their technical expertise, and encouraging them to share acquired knowledge and skills. More specifically, ACOT support ranges from holding conferences and training workshops to providing technical equipment and professional release time.

Conferences

The project provides annual conferences that bring ACOT teachers together to address such issues as creating nontraditional learning environments and adopting leadership roles. The project also enables teachers to attend and make presentations at a variety of other education conferences.

Daily Communication

All sites are linked by a telecommunications network that permits teachers to communicate regularly with one another and with ACOT staff. In addition, the project plans to offer on-line seminars conducted by selected education and technology experts.

Technical Support

ACOT provides its classroom sites with a variety of interactive technologies, allowing all students and teachers ready access to technology at school and, in many cases, at home. ACOT provides the R&D sites with the interactive technologies they need to implement their project goals.

Release Time and Special Projects

ACOT is exploring new ways to provide teachers with professional release time. For instance, at one site, the project funds an additional teaching position to provide release time for all the teachers to work on individual development projects. In fact, ACOT encourages teachers at all sites to submit project proposals for support in reaching particular goals. Support can include consultants, workshops, equipment, release time, and so forth. One such project involves learning to use new software tools to create a combined English/social studies curriculum. Another involves setting up a technology center that makes a variety of interactive technologies available to all ACOT classrooms at the site.

Consultants

The project often provides consultants who can help teachers expand their expertise in particular areas of interest. For instance, last year a multimedia expert spent time in several ACOT classrooms, showing teachers and students how to use a combination of media that promises to enrich the learning experience. In addition, many ACOT teachers have developed expertise in particular areas, and now serve as consultants themselves. For example, teachers at one site developed a successful keyboarding/word processing curriculum that they are currently sharing with other educators.

In-Service Training

Periodically the project brings ACOT educators together to provide feedback on the research that is being done at the sites. This experience enables teachers to learn more about their teaching and to reflect with research experts about how they can further optimize learning through the use of technology.

The project is also preparing a course of study that examines social and learning environments of the 21st century, including the skills people will need and the curriculums and methods of instruction that will best prepare them. The curriculum will be offered to teachers at all sites, and the project is currently exploring telecommunications and other long-distance means to deliver it.

CLASSROOMS

ACOT sites are free to pursue their own goals. Currently, many are developing curriculums that highlight problem solving, independent learning, and effective use of multiple media.

The success of the Apple Classroom of Tomorrow research project depends on the contributions of its participants. Most of them—teachers, students, and ACOT coordinators—work every day in the project's "living laboratories," which include nearly two dozen classrooms with high access to a variety of computer-based technologies.

The sites are free to pursue their own instructional goals and to develop methods of teaching and learning that implement those goals. Within a couple of years, teachers and students have integrated the technology into their daily lives, both at school and at home. Most of the teachers began by using the technology to individualize and enrich a traditional curriculum. Now, guided by the research, many have begun developing new curriculums that highlight skills they see as imperative for the future, such as problem solving, independent learning, and effective use of multiple media.

Each of the public school sites is different. They span the country from Ohio to California, and their populations range from at-risk inner-city youth in Memphis, Tennessee, to the children of rural Blue Earth, Minnesota. The sites' goals and approaches to education are as diverse as their teaching and learning styles, and consequently, each serves as a separate learning laboratory within the larger ACOT project.

Blue Earth, Minnesota

The Blue Earth site is concentrating on individualized learning, multimedia literacy, and global education through telecommunications.

A major goal at the Blue Earth fifth- and sixth-grade site is to individualize learning in math and the language arts. To accomplish this, the classrooms are equipped with networked computers and management software that monitors, evaluates, and reports students' competence in each learning objective. Students progress through curriculum software at their own pace, and at any time the teacher can pinpoint a student's level of competence on any of the objectives. Teachers present lessons in the classroom and use the software to enrich and reinforce learning.

Another site goal is to integrate multimedia and telecommunications tools into the curriculum. Students have already produced four videos, complete with personal interviews, computer graphics, and animation. This year they will telecommunicate with peers around the world and perhaps work collaboratively on certain projects.

Columbus, Ohio

The Columbus site is building an interdisciplinary curriculum that integrates advanced technologies such as robotics, interactive video, digitized music, and hypermedia.

This high school site is building an interdisciplinary curriculum that integrates advanced technologies such as robotics, interactive video, digitized music, and hypermedia. Already teachers have meshed math and science in a project that involves using robotics technology to construct a model of downtown Columbus. The model consists of accurately scaled buildings within a city environment that is controlled by eleven Apple® Macintosh® computers. The robotics include cars, traffic lights, city lights, elevators, a railway crossing, and a construction site with a crane and steel post driver.

Currently the site is extending the team-teaching approach by including students and outside resource people in the creation of interdisciplinary curriculums. Together they are developing a combined art and music curriculum, for instance, and expanding the current publishing and multimedia projects that cover all subject areas.

Cupertino, California

Cupertino ACOT is focusing on writing and problem-solving skills, with the goal of preparing primary students to take greater control of their own learning.

ACOT educators at this primary-level site began right away to explore uses of technology in the area of writing. In collaboration with research experts in writing instruction, they developed a computer-based curriculum in which second and third graders learn keyboarding and word processing skills simultaneously. Within two months, many students can keyboard up to three times faster than they can write by hand.

Another focus of interest at this site is problem solving. Using selected software, teachers can help the children learn to identify and apply strategies for solving a variety of problems. Their goal is to prepare students to solve problems independently and gradually take control of their own learning. Last year, for example, third graders discovered for themselves that note-taking is an effective strategy for solving complex problems. The teachers felt this was an important step toward independent thinking and learning.

Memphis, Tennessee

The Memphis site aims to improve the achievement test scores of its at-risk students.

The Memphis site aims to improve the achievement test scores of at-risk students in the fourth through sixth grades. Given this goal, teachers have been exploring uses of technology that can help students with basic language arts and math skills. For example, they have established an electronic bulletin board system that links sixth-grade students with tutors at Memphis State University. The tutors help with homework assignments and provide personal support.

This year, the Memphis site focuses on improving student reading and writing skills by including teachers, parents, and tutors in the instructional process. Parents, for example, encourage their children to use the site's home software library, and teachers use telecommunications, multimedia, and curriculum software tools to enrich and strengthen their instruction. Specific materials include instructional software with speech enhancement, video, field trips, and guest speakers. These materials are designed to expose students to a wide range of life experiences and to address their various learning styles.

Nashville, Tennessee

Nashville ACOT is primarily concerned with addressing the diverse needs of its fourth graders, who include special education and transitional students, as well as those working at the normal grade level.

Goals for this site take into consideration the diverse abilities of the school's fourth-grade students. One class consists of students who work at the normal fourth-grade level, another includes transitional students who have not quite reached that level, and another class contains special education students.

One way the Nashville ACOT staff meets students' diverse needs is through an individualized math and language arts curriculum that correlates software to the school system's improvement objectives. Another approach is the use of robotics to promote creativity, problem solving, and collaborative learning. Organized into teams, students from all three ability levels work together to invent and build machines or other constructions. Then they write computer programs to control such operations as lighting, music, traffic flow, and so forth. While working on these projects, students continually solve problems as they transform their visions into three-dimensional objects that actually function.

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A Complete List of ACOT Projects
March 1989

Research Studies

The Apple Classroom of Tomorrow™ (ACOT™)program of research includes exploratory and longitudinal studies that examine the potential of technology in high computer access (HCA) environments.

Completed Studies

Assessment in HCA Environments: Problems and Implications
First Year Findings
Dr. Eva Baker and Dr. Joan Herman
University of California at Los Angeles

Student Empowerment in an HCA Environment
An Exploratory Study
Dr. Charles Fisher
University of Colorado

The Influence of HCA on Students' Thinking
Second Year Findings
Dr. Robert Tierney
Ohio State University

The Influence of HyperCard® on Students' Thinking
A Pilot Study
Dr. Robert Tierney
Ohio State University

Distance Tutoring for At-Risk Students
First Year Findings
Dr. Steven Ross
Memphis State University

Teaching Writing in an HCA Classroom
Dr. Elfrieda Hiebert
University of Colorado
Phyllis Vogel
Cupertino Public Schools

Studies-In-Progress

Assessment in HCA Environments: Problems and Implications
Dr. Eva Baker and Dr. Joan Herman
University of California at Los Angeles

The Influence of HCA on Students' Thinking
Dr. Robert Tierney
Ohio State University

The Influence of HyperCard on Students' Thinking
Dr. Robert Tierney
Ohio State University

Distance Tutoring for At-Risk Students
Dr. Steven Ross
Memphis State University

Case Studies of ACOT Students
Dr. Patricia Phelan
Independent Researcher

The Teachers' Experience in HCA Environments
ACOT Staff
Apple Computer

When Students Leave HCA Environments
Dr. Steven Ross
Memphis State University

Classroom Process in HCA Environments
Dr. Eva Baker and Dr. Joan Herman
University of California at Los Angeles

Software in HCA Environments: Effective Characteristics
Freda Husic
Independent Researcher

Studies Proposed for 1989

Computer Use in ACOT Homes
TBA

Student Talk in HCA Learning Environments
TBA

Research & Development Projects

ACOT R&D combines current learning theories with interactive technologies to produce more powerful learning experiences. R&D teams typically work with teachers to build curriculums, tools, and environments that can be integrated into ACOT and other classrooms.

Projects-In-Progress

The Use of Interactive Media to Improve Student Writing
Dr. Glynda Hull and Dr. Marcia Linn
University of California at Berkeley

An Intelligent Tutoring System to Help Students Solve Physics Problems
Dr. R. Bowen Loftin
University of Houston

The Use of Hypermedia to Link Procedural and Conceptual Knowledge in Mathematics
Dr. Ted Hasselbring
Vanderbilt University

Student-Centered Software for Building Problem-Solving Skills
Dr. Jere Confrey
Cornell University

Computer Display and Analysis of Qualitative Research Data
Dr. William Carlsen
Cornell University

Envisioning the Future: A Curriculum for Teachers
Dr. John Thomas
Far West Laboratory

Projects Proposed for 1989

A Collaborative Multimedia Learning Environment
Advanced Technology Group
Product Design Group
Apple Computer

An Intelligent Tutoring System for Biology
Dr. Anthony Kelly
Rutgers University

The Promotion of Integrated Learning Through Collaborative Use of Hypermedia Browsing and Composing Tools
Dr. Roy Pea
The Institute for Research on Learning

The Use of Interactive Diagrams as Tools for Understanding and Using Physics Knowledge about Light
Dr. Roy Pea
The Institute for Research on Learning

Teacher Development Projects

ACOT sponsors teacher development projects that explore curriculums, environments, and technology tools specifically designed for ACOT HCA classrooms. Many of these projects are initiated and implemented by ACOT teachers.

Projects-In-Progress

A Technology Management Database for Teachers in HCA Classrooms
ACOT Staff
Apple Computer

Methods of Increasing Student Empowerment
Dr. Charles Fisher
University of Colorado

Computer Skills Workshops for Parents
Bobby Goodson
Independent Consultant

Visual Literacy for High School Students
Dr. Tim Best
Columbus Public Schools

MIDI Technology in the Music Curriculum
Dr. Robert Carpenter
Columbus Public Schools

Desktop Video as a Learning Tool
Fred D'Ignazio
Multi-Media Classrooms

Professional Working Environments for Teachers
ACOT Staff
Apple Computer

ACOT Telecommunications Network
ACOT Staff
Apple Computer

***Course of Action* as a Hypermedia Tool for Teaching Critical Thinking Skills**
Sheila Cantlebary and Richard Tracy
West High School, Columbus

The Development of Major Hypermedia Projects with Cartridge-Based Storage
Barry Stebbins
West High School, Columbus

The Integration of Diverse Ability Levels in a Multimedia Technology Center
Faye Wilmore
Dodson Elementary School, Nashville

First Graders and Technology: What Works
Linda Oldham
Stevens Creek School, Cupertino

Writing Activities for a Literature-Based Reading Curriculum
Barbara Denver
Stevens Creek School, Cupertino

The Integration of Manipulatives and Technology to Understand Mathematical Concepts
Chris Stortz
Stevens Creek School, Cupertino

A Visual Arts Curriculum for Primary Students
Barbara Bayha
Stevens Creek School, Cupertino

Science Activities for Primary Students
Dan Sabo
Stevens Creek School, Cupertino

For further information about ACOT studies and projects please write to the following ACOT staff members:

Research Studies—David Dwyer
R&D Projects—Wayne Grant
Teacher Development Projects—Keith Yocam

Apple Classroom of Tomorrow (ACOT), Apple Computer, Inc., 20525 Mariani Avenue, M/S 42C, Cupertino, CA 95014. For general information about ACOT, write or call Connie Troy, (408) 974-5219.

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Research Studies
Research & Development Projects

The Apple Classroom of Tomorrow℠ (ACOT℠) is a research project that explores learning when children and teachers have access to interactive technologies.

ACOT explores learning by establishing classroom sites with high computer access (HCA) and by supporting longitudinal research studies that examine the imapct of technology on teaching and learning. ACOT also sponsors research and development projects that directly translate research findings into curriculums, tools, and learning environments that can be integrated into classrooms with computer technology.

The following brief descriptions of research studies and R&D projects illustrate the range and scope of the ACOT research agenda. A complete list of projects and selected summaries of individual projects are available through ACOT. For further information, please contact Connie Troy, Apple Classroom of Tomorrow, Apple Computer, Inc., 20525 Mariani Avenue, M/S 42C, Cupertino, CA 95014; (408) 974-5219.

Original research documents are disseminated through the Educational Resources Information Center (ERIC).

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Research Project

Student Empowerment in a High Computer Access Environment—An Exploratory Study

Charles W. Fisher, Ph.D., University of Colorado

Goal

To examine potential relationships between high computer access (HCA)* and student empowerment*

Description

This exploratory study analyzed descriptive data collected in two fourth-grade classrooms. The researcher observed for one week in an HCA classroom and one week in a classroom without HCA at the same school. He identified indicators of empowerment by analyzing the tasks that constitute students' schoolwork. Then he compared schoolwork in the class with HCA (the ACOT class) to schoolwork in the class without HCA (the non-ACOT class).

The study seeks to verify four major hypotheses: (1) HCA in the instructional environment contributes to student empowerment, (2) students with HCA are more likely to take initiative in shaping the tasks that compose schoolwork, (3) students with HCA more actively consult a variety of information sources, and (4) classrooms with HCA have more information flowing in them.

Data collection consisted of observing and documenting all academic activities during the observation period. Data included extensive field notes, videotapes, recorded interviews, and assorted student materials.

The data were systematically coded and analyzed to identify conditions that affect student empowerment and to explore the primary hypotheses.

Findings

The investigator identified four classroom conditions that affect the level of student empowerment:

- Task shaping—as the level of student task shaping increased, so did the opportunity for student empowerment.
- Task size—as tasks increased in size, so did the opportunity for student empowerment.
- Task complexity—as tasks became more cognitively complex, the opportunity for student empowerment increased. In addition, tasks that required more complex social organization were also more empowering for students.
- Evaluative feedback—feedback that was presented in private settings as opposed to public settings and feedback that was task-related as opposed to person-related were associated with higher levels of student empowerment.

The research indicates that student empowerment fluctuates over time, and although both classrooms experienced varying levels of student empowerment, the ACOT class had a higher average level of student empowerment.

In the ACOT classroom, the four indicators of student empowerment were also related to HCA. The level of student task shaping increased when the level of computer use increased. Larger tasks and complex tasks frequently involved computers directly in their implementation. In addition, the amount of private feedback that was task-related increased when students were working with computers.

Therefore, the results of the study indicate that high access to computers is associated with higher levels of student empowerment.

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* High computer access (HCA) in this study refers to environments where computers are readily available for use by students and teachers. The Apple Classroom of Tomorrow (ACOT) research project supports a number of classroom sites that feature HCA.

** Student empowerment refers to an internal state in which students see themselves as responsible for, in control of, or the source of their own learning.

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Research Project

The Influence of High Computer Access on Students' Thinking—Second Year Findings

Robert Tierney, Ph.D., Ohio State University

Goal

To examine how high computer access (HCA) supports the development of certain thinking skills, especially critical thinking skills

Description

For two years, the research team has been exploring potential relationships between the computer, writing, thought, and learning. Researchers focused on examining the thought proces[illegible]f four tenth-grade students experiencing their second year in the [illegible]A classroom, and five ninth-grade students, experiencing their first year in the HCA environment.

Data collection included: (1) applying measures across time to document student development, (2) observing students' writing behavior to gain insight on their thinking processes, (3) conducting daily interviews with students to probe the nature of their thinking while writing, and (4) conducting general interviews with students to obtain perspective on their use of the computer at school and at home.

The data, in the form of videotaped observations, observational record sheets, and tape-recorded interviews, were logged, transcribed, coded and analyzed.

Findings

The following research findings are a result of investigating the ACOT students' involvement in reading and writing activities.

Ninth-grade students:

- During the first year of HCA, students' approach to doing research for writing assignments changed from being limited to their own thoughts and teachers' suggestions to using more extended resources and carefully considering how they might enhance their work with graphics.
- Students demonstrated an expanding repertoire of planning behaviors as they considered writing topics. They were more sensitive to audience, considered a wider range of ideas, and consulted their peers more extensively as the year progressed.
- Handwritten jot lists as pre-writing activities gave way to more complex mental representations of their ideas which students thought through before and after drafting.
- Graphics became a vital feature of their writing—it assumed a significant role in motivating writing and developing ideas. Graphics also enhanced visualization of thoughts that were difficult for students to express in words.

Tenth-grade students:

- Over a two-year period with HCA, students' planning strategies were influenced by the flexibility of the computer. They tended to type ideas directly into the computer; in fact, they used the computer more readily than pencil and paper. Their writing became a fluid process of getting their ideas down, and then expanding, developing, and revising them through multiple drafts.
- They used graphics to supplement both the development and the presentation of ideas.
- In year two, students continued to make extensive use of peer input during all stages of the writing process.
- Students' revisions included more substantial changes in year two, including reshaping and reorganizing their texts before printing.
- Students in year two (and also by the end of year one) were self-confident about their technology skills. Many tenth graders also claimed to be more fluent, better organized, more comfortable, and more capable writers.

ACOT

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Research Project

The Influence of HyperCard® on Students' Thinking—A Pilot Study

Robert Tierney, Ph.D., Ohio State University

Goal

To explore the effects that multimedia and multi-layered text capabilities might have on the thinking processes of HyperCard® student authors and readers

Description

This pilot study examined a school project in which pairs of ACOT tenth graders chose a chapter from a biology textbook and developed a study guide using HyperCard.

Researchers observed and interviewed students about their experiences as readers and authors of HyperCard stacks. The investigators also asked four ninth graders to compare their experiences reading the biology text and the HyperCard stack. Observation and interview data were then coded and analyzed.

Findings

The following preliminary research results are based on observations and interviews with HyperCard student readers and authors.

Student Readers:

- Readers tended to go beyond a regimented concern for facts and explored ideas and issues of interest.
- Strategies for learning appeared less linear. For example, students reading the HyperCard stack were apt to pause to consider alternative explanations, or check emerging understandings.
- Readers referred more often to visual representations to clarify, enlarge, or check understandings.
- HyperCard appeared to make ideas more accessible.
- HyperCard appeared to have motivational qualities that the regular textbooks did not have.

Student Authors:

- Authors were more sensitive to the liberties readers might assume that they do not assume when reading regular text.
- Working with HyperCard helped student authors expand their views of how HyperCard stacks might be used.
- HyperCard authors gave more consideration to the relationship between function and form, such as the role of visual representation to complement and expand the text explanation.
- On the other hand, HyperCard also seemed to encourage student authors to consider form over content.

Note:
This pilot study emerged from the Tierney longitudinal study on students' thinking processes. The preliminary effort is being followed up by a full year study of the same topic. It is also noteworthy that the findings of the pilot study correspond with those emerging from other studies involving similar technologies (e.g., Levinson, Morrow & Signer, 1986)

[*] HyperCard technology enables writers to encorporate multiple media in one "text." It offers readers the opportunity to select the routes they take through the text because they can move through it in a nonsequential order. The HyperCard author provides optional routes for readers and specific places where they can request additional information. The text then displays information that was not previously visible.

ACOT
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R&D Project

The Use of Interactive Media to Improve Student Writing

Glynda Ann Hull, Ph.D. and Marcia C. Linn, Ph.D., University of California at Berkeley

Goal

To use interactive multimedia as a means to help underprepared college students learn to write effectively and to create multimedia documents

Description

Many college students have difficulty learning to write for academic audiences. But a common strength in contemporary students is their ability to think and work with visual and audio media. This project is based on the belief that students' natural interest and orientation toward visual and audio material will enable them to organize information and express it in these media more easily. Furthermore, the project assumes that organizational skills acquired in multmedia environments will provide a bridge for learning to organize and express information in print.

The R&D team is creating two kinds of multimedia database tools for students. One contains blocks of audio and video information that students can link together to build convincing and powerful documents. The other contains experts' compositional models and their reflections on the composing process, thus providing inexperienced writers with a variety of models from which to choose.

When used together, the two technology tools provide students with a thinking environment in which to study and practice the process of linking ideas. The tools also give students considerable practice and models for working with non-linear blocks of information in a variety of media.

Throughout the development process the team will evaluate the effectiveness of the technology tools for helping students learn to organize ideas and express them clearly.

Findings

The project is currently in the first year of development.

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R&D Project

Student-Centered Software for Building Problem-Solving Skills

Jere Confrey, Ph.D., Cornell University

Goal

To help secondary students construct sound problem-solving strategies for solving real-world problems in mathematics

Description

The R&D team approaches the project with a constructivist view of education that assumes students learn by building their own conceptual models when engaged in compelling problematic contexts.

To help students build conceptual models, the R&D team is creating software and support materials that will provide the following:

- Stimulating problems that are relevant to students at their current level, but still challenge their conceptual framework
- Tools that allow students to compare and integrate their methods of using computation, graphics, tables, and equations to improve their problem-solving ability
- Techniques to promote guided reflection as students discuss and internalize their learning experiences

Findings

The project is currently in the second year of development. When prototype software is finished, the team, in collaboration with teachers at an ACOT site, will investigate how students use the software in problem-solving situations. The results of the research will be used in preparing a final version of the software.

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R&D Project	**An Intelligent Tutoring System to Help Students Solve Physics Problems** R. Bowen Loftin, Ph.D., University of Houston—Downtown An initiative of the NASA/Johnson Space Center Technology Utilization Program
Goal	To help high school students develop more effective strategies for solving physics problems
Description	The R&D team is developing an intelligent tutoring system that can identify students' difficulties and provide feedback and coaching as they progress through the high school physics curriculum. While students work through curriculum lessons, the computer tutor will develop models that reflect their approach to related problems. When the tutor identifies students' misconceptions or difficulties, it will coach them to apply more effective strategies for solving those kinds of problems. The lessons will be adaptable to a variety of texts and teachers will be able to integrate them into their own curriculums. The project will eventually provide a structure for building intelligent tutors that can be used in other academic subjects that require the application of problem-solving skills.
Findings	The project is currently in the first year of development.

Mr. **Roe**. We want to thank you very much. How about the students? Do the students want to add anything? Mr. Chhoa?

Mr. **Chhoa**. I've not prepared a formal statement but—

Mr. **Roe**. Yes. But you're one of the teaching now—you're the teacher now, so you have to be prepared.

[Laughter.]

Mr. **Chhoa**. But instead I want to say something about the impact in the class that do to me personally. First of all, it give me the experience of tomorrows technology today. Second of all, it gives me a—builds me up on self-esteem due to like a family environment in the class, which I'm not afraid to pose any question, even though I think it sounds stupid, otherwise in our class I would not pose. And, finally, the teachers are real friendly. Any question you have, you ask them, they will very nicely answer you totally and will help you to find a solution to solve your problem.

Thank you.

Mr. **Roe**. Miss Cheatham?

Ms. **Cheatham**. I would just like to say, tell how computers have changed my view on academics. First of all, in mathematics and science, computer technology have raised my grades tremendously. Before I got into ACOT, in math I kept D's and F's, and in science I kept low C's and high D's. And now, with use of the computer, I have an A—A in geometry and a high B in science.

In math, we're able to have—we have use of geometry disks, which we can take home and refer to if we don't understand something that is in our book or the teacher didn't explain. The geometry disks go over the chapters of the book that we need help on, and they give examples, and they explain it thoroughly, what we need help on, so that really helped my math.

And in science, before, I thought of it as dull and boring and needed no use of it, but once I got into ACOT—I only found it boring because I really didn't understand what people were trying to teach me in science, or I didn't understand what they were telling me about. But once I got into ACOT, what we learned we would actually see used, visual image of what we were talking about on the laser disk or shown on the computer of stacks that Mr. Stebbins had created for us to see. And this helped me become a little more interested in them, studies in science and math.

And that's all I'd like to say.

Mr. **Roe**. Well, we want to thank you all very much for your testimony, particularly the students. I think this is one of the few times that I can remember since I've been in Congress that we've had students participate with their teachers. And I think that's been already proven to be, and those who are advanced in their careers, it's already obvious to me to be an important element in the decision-making process.

So, number one, I would like to ask a couple of questions. Make a statement first and then ask a couple of questions.

One, what we're really looking for, the purpose of these hearings, although they're advertised as hearings on science and mathematic education—mathematics education, we have put together a series of hearings, as the members of this committee know, over the last three or four months that really relate to science, space and technology and creating the new wealth of the future. How will that be done?

And our fundamental premise is that if we're trying to do the things that have to be done in this country in improving the quality of life and all of the areas and creating the new wealth, the new resources to be able to meet the needs of the 21st century 11 years away, that we have to use the tools we have before us in a global economy and start to adapt and adopt different ideas as to how we can achieve these goals. And there's nothing worse than trying to teach an old dog new tricks, and Congress has a few old dogs around. Not me, of course. But, you know, a few of the others. [Laughter.]

Be that as it may, we have tailored these hearings and invited people at all levels in the science, space and technology areas to come before the committee and present, not from a, or being a pedantic point of view, but from what the real world is, and as you see it.

Now, having said that, that is the purpose of these series of educational hearings that we will be holding. Mr. Walgren, from Pennsylvania, is working on some very important legislation, as is Mr. Boehlert, that has to do with improving our educational skills and institutional processes. But I'm bothered by a few points and a few answers I get. I'm encouraged today from what I've heard, and I'm sorry I didn't hear Mr. Easter and Mr. Howarth. But I know him personally, so—and I'll know more about Mr. Easter, I'm sure, before the day is out.

Having said that, one thing that puzzles me. We asked you selectively to come and participate because of your background and training and some of the innovative things you've done. Not just the idea—what am I trying to say here? Not just the idea of having an idea and not carrying it out. We were—hands on, I think that's been the general presentations made today, and what impact did that have?

In other hearings that we had some folks come and testify in this same broad scoping of the issues involved, we asked them, perhaps, academic questions. I recall one myself. If we have discovered better ways of doing things, why don't we do them? I can't perceive that it's going to take 10 generations. It's too late then for us to be able to even begin to participate in the global economy.

And it's not just the idea of making money. That's not the point. There's a much broader point involved. And the idea, in my judgment, of transmitting and exchanging information is the point that you were making Mr. Stebbins, as I heard it.

One of the answers we got back, and puzzle this with me for a moment—and I remember it well—was, well, in some people's opinion you had—the educational process had to be adapted to the regional relationship or the particular institution and had to emerge from that institution, and, in effect, that the process was only as good as the people that were doing the teaching per se, which seem logical, I think, in part.

However, what puzzles me, if we have discovered a new method that begins to say something about writing a textbook—and there's, I don't know how many textbooks there are and who does all this work in the country. But if we've discovered that there is a better way of using a textbook and designing a textbook that accelerates the interest of the teaching process, why should it not start to form a national policy? If we have determined with the use of a—and I'm sorry, but I have to give you, I guess a—on the television, we've got to give you an A-plus, Mr. Grant, having to do with the Apple computer. But, if the students have learned through that process—and there's other computers too, in fair play. Not maybe as good as Apple, but—

[Laughter.]

Well, that might be the case. If that's the case, then it appears to me that the computer approach is an important tool, which we've learned. Are we adapting that? Should we adapt that more? Why should it not be that we can't afford to be able to provide microscopes, even to read the newspaper, versus the point of view of laser disks, as you pointed out, which are less expensive and more productive as far as the person is concerned?

Why do we talk about students starting on the junior high school level or—yes, junior high school level, start to become interested in science, space and technology, when that is the whole total tool you're talking about?

Why do we start at that late time? Why don't we start—just make it a national policy and start in the third grade or the first grade? And say that that's what the policy is going to be and let's go do it?

Now people come back and say to us, well, it's not really the mores of the tribe. It's going to take longer to do that. I can't believe that. I don't know where my tribe was in this whole thing. I can still screw in a light bulb here and there and make it work, I think.

[Laughter.]

But there's the type of things we want to nail down. And then, if we want to be just—and I'm being a little too loquacious. If we want to be just a little bit firmer, we've got to come back and say: We are the Science, Space, and Technology Committee. We have a vested interest in what you're going to be doing in biotechnology or in biology and what you're going to pick up from there and go on.

We can design, and we have designed programs and we've passed into law, with both Mr. Walgren and Mr. Boehlert's subcommittee, some very advanced views. And that's what the purpose, again, of these hearings is going to be about.

Now, I'd like to see this committee take a quantum step forward. It bothers me, if we have something that works, that we're only testing it here and there, when we lose a generation—I would think of mine. Now that, we then are now starting to tread—and let me share with you. I'm going to go through the learning process, Members of Congress, and the students and the academic world and guests. We start to tread on some toes, and the toes we tread upon is the basic broad-based educational policy of the Nation. We can—through the National Science Foundation, we can nail down specific direction.

Now, my question. God, that's a long way to ask a question.

[Laughter.]

And you just got done telling me you should listen more and let the students teach us rather than being pedantic.

Be that as it may, let me ask this question. Is the broad—and it's probably academic—the broad-based process in the country of teaching science, space and technology particularly, and maybe English and a lot of other things—and you spoke about foreign languages being used and so forth. Do we need a broad-based readjustment of the educational teaching processes of the country as a national goal?

Mr. STEBBINS. Let me make one suggestion here that I think would probably help the education community more than anything else, and this is a bias I have. One of the successes or failures of the education system is being measured by standardized tests, the SAT, the ACT, and a student who has the ability to memorize facts, whether they're important facts or trivial facts, may possibly be able to score very high on that test. However, in making a test that is easy to grade and quick to give you results on, we have often eliminated the thought, decision-making process. We stopped working on those skills which are important for learning and acquiring new information, the skills which are necessary for creating that new information, that new technology base you were alluding to, and we're rewarding the memorization of fact content in science classes.

I believe Sylvia referred to the fact of a need-to-know basis, rather than you must know everything there is to know about chemistry to pass the chemistry class. So, if our students learn how to learn and how to use information and how to communicate and all those important skills, are rewarded for taking risks and coming up with creative ideas, and that's seen as a positive rather than the fact the kid didn't know that Columbus sailed and discovered America in 1492—which is a fact, you know. Did we learn anything about the process he went through in that discovery or are we just memorizing that fact?

However, the ACT and the SAT, I think College Boards in general, are looking at the recall of various facts, and we judge success based on that. I believe many States have set up a process where they evaluate also the success of teachers and schools based on how well kids do on standardized tests. Now, if that's important, then one of the things I see happening around the country is that teachers and school systems are now teaching how to do well on that test, rather than teaching the process of learning to communicate.

Mr. ROE. Well, will the gentleman yield on that point? I think you're striking at an extremely important point.

Mr. STEBBINS. So—

Mr. ROE. Because as it is around—that we're running into, is that if a student can't do well on the SATs and so forth, they can't even get into a university. And it really doesn't have to do with their—what would you say?—their thought process, as you're pointing out.

Mr. STEBBINS. Right. I would suggest that, you know, many people are saying that the amount of information there is to know, if you could put that into one pile, whatever that pile is, that that pile is doubling at slightly under a year.

Mr. ROE. Um-hum.

Mr. STEBBINS. In terms of time. So, if the amount of information there is to know today is doubling every year or in a shorter period, how can an SAT or an ACT or a standardized test keep up with all the things there are to know?

Mr. ROE. Well, are you saying fundamentally—if the gentleman would yield further—that by being stuck or making it an absolute basic foundation fact of the educational process that it's going to stymy any new ways of teaching?

Mr. STEBBINS. I think it will.

Mr. ROE. Is that a fair comment to make?

Mr. STEBBINS. Because we're going to evaluate my success as a teacher on how well my students do on the standardized test.

Mr. ROE. Rather than the point of whether they can carry on an experiment and know what they're doing.

Mr. STEBBINS. Right. Right. So, if maybe Congress mandates that standardized tests are a no-no and allows us to experiment—

Mr. ROE. That might take a bit of doing.

Ms. WARE. If I might comment here, since I'm engaged in producing another standardized test. I've often heard it said that, if you could have the perfect test, you would be able to devise the perfect curriculum, which is an aside on that.

I'd like to make a couple of comments addressing your particular question, but before I do I'd like to proudly announce that Mr. Stebbins' school teaches ChemCom.

Mr. ROE. Somehow we figured that out.

Ms. WARE. And I just found that out a few minutes ago. And I'd personally like to associate myself with everything that he has said.

I'd like to address your particular question by suggesting that it's something to do with national values. There does not seem to be a real national commitment to education, and there especially does not seem to be an understanding of the vital importance of the sciences in today's world. We talk about reading, writing, and arithmetic, back to the basics. I would propound that through science we could be teaching reasoning to our students, and that the most valuable thing that we can do with science, even if we don't turn out more scientists, is to produce a generation of people who are capable of looking at various problems in the community and applying the scientific method to their solution.

I know that ChemCom works in many classrooms, but it doesn't work in all classrooms. Because there is a tremendous resistance to change within our educational system. In order to be the kind of teacher you need to be with ChemCom, in order to be the kind of teacher that Barry obviously is, you have to give up the authoritarian role. You become, as he said, a learner as well as a teacher. You become a manager of the classroom. And a lot of teachers are not prepared to give up the authority position that they have in the classroom.

When you've taught the same way for 25 years, being asked to do something different is very, very threatening. And I do not underestimate the extent of resistance to the kind of approach that we are suggesting. Many teachers, in fact, have been very successful with the old approach, but only with a very small number of students.

Mr. ROE. Dr. Layman?

Dr. LAYMAN. Going back to my earlier comments on the microcomputer-based laboratories, one of the things that we're being told by our teachers who are working with groups in the four surrounding counties is that this is a technology that really allows all students access to science. It's culture free. It's language free. In our area, of course, we have a lot of students for whom English is not their primary language. Once they've learned to operate the computer and can interrogate nature for the information she will give us, they are ready and up and running, and they're not dependent upon the text, nor the teacher.

So we have an obligation on the part of those who of us doing these projects to share the information we glean from this to show that it is indeed a major contribution for the students and their understanding science. And it takes a small amount of time to get that across to the point where districts and others are willing to make the monetary commitment that it takes to provide microcomputers for junior high kids, and even elementary kids, to give them the personal power to deal with science in a way that they haven't been able to in the past.

Mr. ROE. Dr. Easter?

Mr. EASTER. Mr. Easter. Thank you—

Mr. ROE. Mr. Easter?

Mr. EASTER. —Mr. Chairman. Yes.

Mr. ROE. They used to call me "Doctor" too, Mr. Easter. [Laughter.]

Mr. EASTER. I want neither to be a doctor nor a lawyer. [Laughter.]

Mr. ROE. I'm pleased that you didn't say a politician.

Mr. EASTER. No. No. I did not.

I'm struck. I need to observe that, while it is a fact that Christopher Columbus sailed to these shores in 1492, it is a fact that there were people that knew it was here, and that's something that I think as a nation we need to come to grips with. A non-Eurocentric view of the world is a part of our meeting the competition from the Pacific Rim, for instance, which you hear a lot of in California, where I'm from.

But you asked a question and I think the answer to the question is no. I think that the problem with education in the United States today primarily is that we do not value teachers. We pay almost everyone more than we pay teachers. Plumbers earn more. Electricians earn more. There are cab drivers in New York that out-earn teachers. So it is clearly more—I learned this morning that cab drivers in the city of Washington, D.C., do not out-earn teachers, but that's an aside.

It seems to me that we have to make of that profession what we want from it. If we want the people who teach our children to produce the finest minds in the world, then I think we have to pay them—not just pay them to do it, but pay to draw other people into the profession who will do that, who has that as both a possibility and a goal.

I think we also need to train teachers to work with all Americans to see the strengths that exist in all Americans. Too much of what we do in assessing strength assigns ability to what most resembles one's self.

The other—and you asked a question about why we are testing things here and there. Primarily because foundations, which fund must of the experimentation in education, fund new things. It's the hardest thing in the world for an organization like mine to try to find $5 million to do what we did successfully last year. If I want to do something different, if I want to play around and try it, standing on one leg and with one hand in my pocket, then I can get money to try to do that. But to say: Hey, we had 5,000 kids we brought through last year. If you give me this money again I can bring 5,000 through again next year. They say: No. Well. I mean, what else can you do?

Mr. ROE. Well, if the gentleman would yield. I think you're striking at something. In other words, there's someplace along the line in science, space and technology, even in our space program, you've got to make a determination to fly. We can't be doing the research forever or we'll never get to the moon, or back to the moon or whatever we decide to do.

Having said that, I think that the point you're making is extremely valid. There's a number of points being made that are valid here today. Is that we have to figure out from a legislative process how we take and achieve just what you've got done saying. We ought to be able to come back and say: Well, okay; if we've gotten to that point—the same thing you talked about, your textbook—where it now works, we have to translate that and to at least do part of a mosaic of a national policy. That's the point I'm trying to make.

I'm not against any tinkering. If we do tinkering 25 hours a day it doesn't bother me at all. But someplace we've got to say, if that is a good idea and it does work and it did work and it can work, let's go do it.

Mr. EASTER. Make it possible in a widespread fashion. Right.

Mr. ROE. That's what I'm saying. Now we're having—and let me be up front with you. We're having the same difficulty, I think, as you are, coming from, you know, the academic world and the students' world, if you like, and the new processes we're talking about, for us to be able to forge new processes here in Congress because we're subject to the same prejudices. We're subject to the same old rote and so forth and so on.

What these hearings we hope will achieve will be a methodology to break through that, even if it's just a major step, or if we can make a quantum step. And if we have to do it—and what's going through my mind, and I've talked to Doug about that, is that if we would set up a specific pilot program in each State, for example, and say: From our testimony we have observed the following: In this particular area this work. In this particular area this work. In this particular area that work. Therefore, under the aegis of this committee, without discombobulating or scaring the living hell, if you'll pardon my language, out of the educational community, we could at least take and start to institutionalize a process to move ahead—is what we're trying to achieve.

Mr. EASTER. I quite agree.

Mr. ROE. Further comments?

Mr. Howarth?

Mr. HOWARTH. Mr. Chairman, I'd like to pick up on your suggestion that we need to start earlier, third grade or even first grade, because I think that's very much on target. I mentioned earlier that, by junior high, only about a quarter of our young people still express interest in science; and, if we're serious about increasing the flow through the pipeline, it has to start, really, in the very early grades.

It seems to me that at that level the real problem is primarily one of support and training for teachers. My personal opinion is that we've got curriculum that works, much of it from the NSF-funded programs of the '60s and '70s. Good materials--ESS, SCIS—and proven materials. But they never really accomplished what they set out to accomplish. Many of those materials ended up sitting in closets, and the reason wasn't because the curriculum was no good, it was because the teachers had neither the training to use it nor, indeed, the support. When they got back to the classroom after being trained, you try the first experiment, it doesn't work, and that's it. Because I knew it wasn't going to work, it doesn't work, and it goes in the closet.

So it seems to me that at that level, which I consider to be the critical level, there's a terrible need to increase the level of support for teachers and the level of training for teachers. I mentioned earlier that this is something that science museums and science centers are particularly interested in. I think it's a natural constituency for these organizations. And I might add to that, that with regard to a Federal role, the problem is really one of dissemination; and that is, picking up on what Mr. Easter said, we've got proven training programs out there now working in communities across the country, but in far too few communities. And, if there were a way to replicate the best training programs more broadly—I'm thinking now specifically within my own industry, the museum business, but I suspect that the point is more generally applicable. If there was a way to take tried and true and proven programs from Chicago or the Lawrence Hall or Boston, and then replicate them for other communities through starting new science centers, I think that would make a big difference, particularly at the elementary level.

I might add a point that I meant to get into earlier but didn't, which is that at present, looking at NSF, NSF not only doesn't support programs for new science centers; it actually refuses to support new science centers at all. And anyway, there is no support for start-up. The support can only go to established organizations. So it really seems to me to weave together a couple of disparate threads here. What I'm saying is, I think we have the tools and the opportunity would be to disseminate them more broadly, and where the Federal role could be very helpful would be in leveraging that dissemination through support for replicating programs that work.

Mr. PYSNIK. I'll take the "baddy" first. I always hate to end up on a bad note, so let me just take what was just mentioned.

When we talk about NSF support, one of the points that I made in my testimony, and I did it with a lot of trepidation, was NSF support of research programs in the school itself in terms of equipment purchase, etc. I lead two lives. I'm a research associate at

Ithaca College, and I also teach at Sidney High School. I see the funding in terms of programs and equipment, and certainly that equipment is worthy of use; yet I compare the lack of success that I've had to being able to obtain equipment and development curriculum programs through NSF funding. And that's been something that I wanted to make sure that I again pointed out and highlighted. But so much for the "baddies."

I thought of something really neat that we've been able to note even at little Sidney, and it just popped altogether. We have a number of Rotary exchange students who come to Sidney from all over the world, and when they come there, typically, those students have had one, two, sometimes even three years of science, chemistry. They can beat the pants off of our students in terms of spewing out the information. And yet, and I'm speaking now of the students at Sidney because, you know, we've developed more the research aspect, we have de-emphasized to some extent, within the limits of the Board of Regents, how much has to be memorized. Our students spend an incredible amount of time getting those Rotary exchange students up to par in terms of working with their hands and becoming the scientist.

We've discovered that, if we can give that research effort, we certainly can excel in the region that the international counterparts don't. For instance, just think of it. How many international students, perhaps, have you seen on a college campus has come to the United States for undergraduate and graduate work to get the good, hands-on experience? I maintain that we can do the same prior to that undergraduate and graduate work. We can do it in the schools. The hands-on work is essential.

Ms. WARE. Could I make one more point? I think another answer to your problem is simply to do with size of effort. This is an absolutely geographically enormous country. You have a 50-state structure. You have problems throughout the pipeline, from kindergarten through graduate education, and there are people all over this country working on particular facets of the problem and not necessarily talking to each other.

One trend that I have noticed this year that I think is extremely helpful to a final solution of the problem is that we're all beginning to talk to each other. So, instead of having the American Physical Society or the American Institute of Physics doing its programs in one corner and the American Chemical Society in another, and MESA in another, we're all beginning to talk to each other about how we can put all our efforts together into a collective solution in particular communities. For example, we are talking to MESA now about putting one of our programs, Project Seed, which gives research experiences to economically disadvantaged students, into one of their MESA communities, so that we can multiply the effect of what we do.

We also have a comic book for fourth graders that so far we've only produced four times a year, because we didn't have the money to do it any more than that, and we are now going to be producing it eight times a year, with the American Institute of Physics.

And I see societies and museum groups and State educators forming coalitions across the country to get together to address these range of programs. And I would suggest that anything that you can do to support coalition building, to say that it is not just enough to work alone in a particular community but you have to mobilize the total resources of a community, then that would be extremely helpful for all of us. Because I think it's the way we've got to move.

Mr. ROE. Dr. Layman?

Dr. LAYMAN. Let me return to a comment that I made earlier about the Physics Teaching Resource Agents. You're indicating concern with turnaround time, the fact that a good idea may occur today and it may be 15 or 20 years before it can be found in the average school. If we would marshal our resources and keep track of these highly talented teachers that have been to all kinds of Federal programs, and share with them the know-how, how to take advantage of Title II monies, for instance. There are monies there for the use of science, technology. They are in the schools. They are guaranteed to be there. If we had 2,000 or 3,000 students, or teachers who knew by far how to access those monies, we would have a program in place in very much shorter if that works in parallel with any efforts that your committee could be made or the representatives in the various parts of the country. We have that national network in place. We simply have to continue supporting it and taking advantage of it.

Mr. ROE. Let me—I agree. Let me just—Mr. Pysnik did not have a chance to finish.

Mr. PYSNIK. One of the things that I wanted to add was that perhaps in the interim as we're trying to develop that global type of work that, why not find those outstanding programs and teachers and let them, help them, to go out and show others or bring other teachers and students to them to build. I think that is a must. In other words—for instance, typically, we talked about science institutes at colleges themselves. Why not have a program, for instance, in Columbus, whereby students, other than at that school, at other times, could go there and see how the program works. Other teachers, have them go there and see how that program works. Why not have students in the area around Sidney, for instance, be able to come and share that work with us? Develop the seeds of interest and then move on. I think that's what we need to do.

Mr. ROE. Okay. Let me—I want to thank my colleagues for indulging me. I was late this morning because I was in New Jersey. But now I want to call on our distinguished Subcommittee Chairman, Mr. Walgren, for any comments he wants to make, because he has to go someplace to another meeting.

Mr. WALGREN. Well, thank you very much, Mr. Chairman. And I want to express appreciation for the contributions of all you, the witnesses today. I think you've kind of hiked this up on a pretty interesting plane about the question of how we get people to be interested and then how we recognize that interest and bring them on through the system.

I was—it was running through my mind that the importance that, Mr. Pysnik, you put on self-esteem and the idea that the student wanted to view themselves as a scientist and how important that was for them, in a sense wanting to appreciate themselves and be appreciated. The same is true with the emphasis on teacher training and the idea of professionalism, wanting to receive an honorarium to symbolize their professionalism and the need for ongoing training of these teachers. Because apparently when they're dropped there, then something didn't happen. But if they were able to be reinvolved and continually involved in a training program, they begin to see themselves differently and function as agents in this one program better than they would if they're just trained and then put out there.

And I'm just trying to think of what it is that happens when they make a research discovery as a scientist, a high school student or a college student. What's so interesting about making a research discovery or being able to take, or being involved in the process of taking facts and deducing something from it that might not have been given to you already, as the answer in the back of the book or maybe even working in a research project that was finding out new data or something new? And somewhere along the line it comes back to wanting to feel that as an individual they're making a difference, in the trite sense of the word. That they have contributed a unique little bit of knowledge, that they are unique, and that's very basic, of course, to all our interests. And the idea that we don't make a difference is very debilitating and crushing spiritually.

Well, the question then is how do you do that? How do you make them get that sense of appreciation and that understanding of their uniqueness? And one of the things that's been running through some of our thoughts is that, obviously, you've got to be paired in order to get appreciation from some other entity outside yourself, and the program out of California, the MESA thing, apparently pairs people pretty completely, or at least follows them in a very special way as individuals.

I've had this thought of every engineer should be a teacher in a way, and the problem is they're not connected to others. And how do you connect them? Can you set up a network where practicing engineers or practicing scientists out there are brought back together with students on a very individual basis and connected in a way that that sense of appreciation and context of the individual can be developed?

Mr. **Easter**. We do that. Yes.

Mr. **Walgren**. You do that, don't you?

Mr. **Easter**. Sure. Bring them into the classroom. So that—I mean, our philosophy is that a kid can't be one if he can't see one.

Mr. **Pysnik**. That's occurring more and more. More and more you will find a welcome smile on individuals' faces from business when they can actually be part of that. Because in many instances it's their own kids there.

Mr. **Walgren**. All right. But what I'm driving towards anyway is how you get it down to that level that there can be personal appreciation of the contribution of the student, and it seems to me that we need to get—and it has obviously been said by so many, but substantially more private sector involvement. And it strikes me that the private sector isn't really in here.

In ChemCom, it was two-thirds Government money, one-third chemistry association money, and the chemistry association is one of the most highly motivated groups around. So it was still essentially governmental. In the New York research project area you had, you were saying in your testimony that there were some 12 projects, 11 of which seem to be governmentally orchestrated or organized and one was organized by a private sector group.

And I, what I'm fishing for is how we can get these private sector people in here, coupled personally into the program. Is that an area that seems to you to be worth trying to pursue?

Ms. **Ware**. Could I clarify one point? By the time the ChemCom project is completely finished, the amount of money that has come from NSF to the amount of money that will be coming from the American Chemical Society will be closer to the ratio of 1-to-4, with the American Chemical Society coming up with the 4. It was the initial development stage only in which the National Science Foundation put in twice as much money as we did. But since that point we have been putting more and more of our money in it.

Mr. **Walgren**. Well, that's good.

Mr. Howarth?

Mr. **Howarth**. Mr. Walgren, my own project is about 75 percent privately funded and, I think I mentioned earlier, initiated primarily by the corporate sector in collaboration with the universities.

Mr. **Walgren**. As are almost all of the science museums, I understand. Certainly not federally funded.

Mr. **Howarth**. No, they're not federally funded. None of them are federally funded. In fact, there's no mechanism to do that, although there is a mechanism for art and history museums. But not for science museums.

Mr. **Walgren**. But not on the scale on that we need to talk about, either, I don't think.

Mr. **Howarth**. I'm sorry? You—well, in any case, I think that the private sector initiative science center business is actually unusual. The most common source of financing is local government, but in this particular case it's corporate initiative. But my perception is that the corporate community is very, very anxious to find ways to get in and help solve this problem. It's partly a question of giving them a mechanism to do that because for the most part we're outside their area of expertise and there is no easy way for them to link up with the schools. I think they see this, my own project, in fact, as a way to do that. We're a link that links the corporate and academic communities to the schools.

Mr. **Pysnik**. Of the $1.2 million worth of high technology equipment that we have at Sidney, I would say over 80 percent has been donated by industry in terms of wanting to encourage student use, in some instances training by the people from industry—

Mr. **Walgren**. But the key that you talked about, though, is that sense of self. That sense of appreciation. Seeing themselves as a scientist, and I think that implies other eyes looking at them in the same way.

Mr. **Pysnik**. Exactly.

Mr. **Walgren**. I think that implies that. And where are these other eyes? How can we increase the coupling of people in this? Maybe I'm wrong in pursuing that approach.

Mr. **Pysnik**. I guess what I'm suggesting is that I think the coupling is more there than perhaps we realize, except that it's not on a formal basis.

Mr. **Walgren**. Well, it's apparently not there in two-thirds of the teachers. Because, as you describe yourself as idiosyncratic, we apparently have two-thirds of the teachers wanting to teach the book, and I guess that means lecture, and I guess that means pretty boring stuff, and not change. And, if we had more idiosyncratic teachers, I guess I would feel maybe that personal inspiration and personal recognition was there more than I'm afraid it might be.

But I think the evidence is, it's not there. And one approach is to train the teacher, and the evidence—we've been told you have to go back and teach the teacher to be a scientist. Not so much teach them to teach science, you have to teach them to be a scientist. And what do you do when you do that? You teach them to find out interesting things, I gather. You teach him to—him or her to get that appreciation of making the next connection that has not been made. What does that do to them? Well, maybe it helps them relate to other individuals or to individual students. Rather than teach them, it helps them relate to them with some degree of excitement or appreciation of uniqueness.

I'm sorry. I babble on too, also.

Mr. **Easter**. But I have to say, Mr. Walgren, that, in California, where there is for the first time in this country no ethnic majority, California corporations are very interested in developing a highly trained, technologically literate employee base from among populations that traditionally have not supplied that base, and so they are adopting schools, they are lending executives, they are putting their money where their mouth is, really, supporting programs like ours, supporting schools directly, in partnerships with districts. It would be hard to fault, I think, the California industry, business industrial community.

Mr. **Roe**. Will the gentleman yield? I'm sorry.

Mr. **Walgren**. Mr. Stebbins had a comment.

Mr. **Stebbins**. Yes. You were asking about how you could pull some of this off in private sector involvement. Somebody alluded to the fact of paying teachers more, and, you know, I would certainly appreciate more money. But the thing I'm seeing that is most important to me right now at this stage in my life and the people I'm working with is the recognition we're getting. When Apple got involved with us, they gave us a computer that was in a sense untried in education. And they said: Here. Try it. See what you can do with it and tell us what we can do with it. They listened to us, and in a sense they made us the expert in that field.

Then they did one other thing. They said, "If you could change this computer, how would you design it? What kind of things would you do?" And they also ask our students that. So, in a sense, here is a business who is willing to take the risk of us suggesting new ways that their computer could be used, new designs, a totally new format. They have made it possible for us to sit down with software developers, and say: You know, your software is pretty decent but if it did this, this and this and this. And you know what surprised me? They listened to me, the teacher, and are going to design the tool that I wanted. So all of a sudden, my input was very important and I was rewarded for that.

Perceptronics, who builds some of your military and research—not research—simulators—

Mr. WALGREN. Well, let me ask you something.

Mr. STEBBINS. Yes.

Mr. WALGREN. Let me ask you something, we hear alot about the private industry donating equipment. What you're saying is the important thing is, is that they set up a program in which there were some other ears to hear what you were saying.

Mr. STEBBINS. Right.

Mr. WALGREN. What you appreciate was the ability to be part of a communication between—

Mr. STEBBINS. Correct.

Mr. WALGREN. —between actual human beings.

Mr. STEBBINS. Somebody suggested—

Mr. WALGREN. And so my point is, don't we have to push these programs to maximize that element of it as opposed to the equipment contribution? ChemCom doesn't even need any equipment. And, if it's a good program, and I've looked at the book and I think it is, you don't need lots of laboratory equipment to pursue that course.

Mr. STEBBINS. Right.

Mr. WALGREN. Now the Apple thing is very appreciated and we need equipment, that's the point. Or that's really real. But fundamentally, we really have to pursue this human contact, whatever it is, because that's where the interest and the motivation comes from.

Mr. STEBBINS. Yes.

Mr. WALGREN. Well, I've taken too much time, Mr. Chairman. I appreciate—

Mr. ROE. No. I think—don't you dare get away. I think you're hitting it right on the head.

Well, I want to stress, and I feel—if the gentleman would yield. I feel that when we—you can feel excitement and interest here. The reason we have not had more members is because we have a, you know, a head of state at the Congress this morning. That's what happened to us. But be that as it may, the important ones are here.

[Laughter.]

Mr. ROE. Getting on with that—

Mr. EASTER. Here! Here!

[Laughter.]

Mr. ROE. I believe that when we have these hearings it is—I've been here 21 years—if you'll indulge me for a moment, fellow citizens—it's not the idea to just say, well, here's the idea, and that was the point you made, Mr. Pysnik. Very clearly, that you hope that something happens or at least we'll keep in contact. Believe me, we intend to.

Where I'm going from, the value of today's exchange of dialogue and the thoughts and ideas expressed has to be converted into something tangible and productive. I mean, I think I heard enough here to say that.

Now, it seems to me, and I don't know how you feel about it, but in my lifetime I want to make a difference, God willing, in people's lives. That's what I ran for Congress for in the first place. Otherwise, I'm only serving myself, and I don't need that.

So, unless we can translate what you've said this morning into a tangible foundation, and say how do we do that and make it work—my father used to, when he'd come home, he'd say let's see what we were all worrying about. I mean, we've got to get beyond that point. So, if what you're doing works, if what you're doing we know it will work. What you're doing in California, we know it works. You may a very telling point and industry is hearing us. Somebody made that comment. Industry is beginning to hear. Industry is hearing because the future economic dynamics of this country are based on science, space and technology and industry has to develop that expertise.

How do we come off spending hundreds of millions of dollars, which you're doing now, on retraining workers to what, work in McDonald's? I mean, that's basically what we're talking about. Should we—and I don't run down McDonald's. Their hamburgers are a little much, but whatever. Is the idea being that we should use our resources to train those teachers? And the answer, of course, it is that we should.

It's clearly the question, and it's going through my mind. What about setting—and I think one other point and then let me pose the thought process. One other point is, how do we learn what you're doing? We would not have learned on this opinion-making body here if we didn't have the hearing and you didn't come from all over the country to help educate us too. So what's to be, if you have the feeling—in my State I got what?—7-1/2 million people. In fact, all of us represent 600,000 people in each one of our respective districts. I'm not sure how many people know Walgren or Roe, but enough do to get us elected. But there's an awful lot of people don't even know what Congress does. Maybe that's good, I don't know. [Laughter.]

Mr. Roe. Be that as it may, how about the idea of establishing the thought process of a national innovative educational center, where we could have a center to focus the new ideas, that would build its prestige? If we have military academies, and we have them for a purpose, whatever that purpose may be—and I'm not looking to invent another creature or another—but should we not have a center of expertise where these ideas can be tried, and these ideas can be put into national focus?

I mean, the television is showing some people today what we're talking about, but we've got to get a broader base out there, to both the opinion-makers and the educators, to start to implement what you're trying to do. Does that make sense?

Mr. Easter. Absolutely.

Mr. Roe. Okay. Any other further comments from any other members? The gentleman from California is recognized, Mr. Mineta?

Mr. Mineta. Thank you very much, Mr. Chairman. I apologize for not having been here earlier, but you pointed out some of the other competing issues that we have before us. I just would like to pose a general question to the panel.

What is it that drives or interests students in science, math and engineering? Is it something—is it their parents saying, "Do this"? Is it something that, I don't know, the computers that they get exposed to? Is it something in the news dealing with the space program? Space Station, is that something that may whet their appetite to go into math, science and engineering?

There's a—the reason I ask is there's sort of a theory, a hypothesis being promoted to say that things like exposure to science, or rather to space programs, Space Station, do whet the appetite of the young to pursue interests and careers in math, science and engineering. I'm not sure that we have any kind of good hard data on that, as to whether or not the number of degrees that are being granted in math, science and engineering reflect what's happening to the budget, let's say, on Space Station. Maybe we may be able to find some correlation between Space Station interest and the interest of young people in math, science and engineering.

Is there anything, to just sort of come back on that? Dr. Layman?

Mr. LAYMAN. Mr. Mineta, all of those things certainly influence students and decisions on careers. But, if we are concerned with all students being participants in science, then I think we have to find ways that gives them personal access. We've criticized textbooks and stylized laboratories. We've claimed that technology may help this a bit. But, again, if technology allows each of the students, whatever their background and interest, to feel that they have succeeded in science in some way in a personal manner, then I think a broader set of these students will feel that perhaps science and mathematics and technology is worthy of a career thought as well.

But I think we have to begin at the lower grades and we have to change the science in a ChemCom sense or an MBL sense—Microcomputer-Based Laboratories—so that whatever science students encounter, it's a personal encounter and the information they've gained about the world is their own, not something handed out by the textbook or dictated by the teacher or responded to because of the SATs to be taken or something of that sort.

Mr. STEBBINS. Mr. Mineta, I'd also suggest that this personal experience that is being referred to, one of the things that I try and do in a science lab is, if I have 10 triple beam balances, then I figure a way that only 10 students can work at time and make a rotation that all 30 of my students get hands-on with that piece of equipment. Whatever that experience is, that each student participates in on their own, having total access to whatever that experience is, if each student becomes involved, they're naturally curious.

Now one of the things I think we have documented fairly well is that a 3-year-old is very inquisitive about the entire world around them. But somewhere, by the time that kid is now fifteen years old, we have killed that interest or done something to stymy that kid's exploration of his world, the development of his own information and knowledge base. Because we have made kids into observers, rather than participators. You know, we are a nation of observers when it comes to sports. We have a few people who play basketball. Right now we're down to two teams, and how many of us are watching that happen? You know, I would guess that there are millions of sports fans out there who are watching basketball take place. How many students sit in a science classroom or a math classroom or any classroom and watch that process take place. Do we have science labs where each kid participates in science, or is like the '70s where we had the big push with the NSF money and we bought 10 balances for a 35-student lab? We were mass producing science students, and we had exactly nine months in the average school to get students from September to June and out the door. We did not allow them to proceed at their own pace. We prevented them because somebody had to watch. When there's one microscope to five students, one student is all that can adjust that microscope. When there's one balance, whatever the piece of equipment is, whatever the experience is, each student needs to experience that.

Mr. **Pysnik**. I think there's a lot of—

Mr. **Easter**. Let's hear from the students.

Mr. **Pysnik**. Yes.

Mr. **Stebbins**. I'd like to.

Mr. **Suriano**. I think the final product of the student, what do you want out of it, do you want a student that knows a general area or do you want a scientist to come out? If we want to educate the general public about sciences, then some of these programs are fine. But they are not very specific. They're not giving a student the hands-on. To be able to grab that microscope, even if it is only for one out of five people, to get in there and see it and play with it, that's where all the fun is. Not to punch it up on the computer and this is what it would look like if I had one. I want to be able to play with it myself. You know, hold it, look at it, experiment with things like that. That's what is exciting.

Mr. **Mineta**. Thank you very much. Thank you.

Mr. **Roe**. Before I—if there's no further—

Mr. **Pysnik**. Excuse me. May I just—

Mr. **Roe**. Oh. Excuse me. Yes.

Mr. **Pysnik**. May I just add one more thing?

Mr. **Roe**. Surely.

Mr. **Pysnik**. There's another element that, you know, the other people that are involved in education here show and, hopefully, I show too. And I don't know you do this, but without the enthusiastic learning and teaching that the teacher is also doing with the student, we've lost it all. And that's the only thing that I can't help you quantify.

Thank you.

Mr. **Roe**. Well, let me close on this point because we have other hearings that are going to take place shortly. The—there's all kinds of nuances and vicissitudes that have gone through this discussion today. I'm sure we've been all picking up on it as we go. And sifting through it, we're beginning to see a half dozen, Kerri, as where we can move. I think the point you made about the enthusiastic teacher goes to academic basis. Okay, if I can't feed my family, how can I afford to teach?

Mr. **Easter**. Exactly.

Mr. **Roe**. I mean, that's reasonable. You know what I mean?

Mr. **Easter**. Yes, sir.

Mr. **Roe**. And I think you brought in both the sociological relationships and the academic end of it, and with the students' participation.

So we want to thank you very, very much for your input today, and it will help us a long way in getting some of the additional legislation that's going to be needed to start to direct national policy, which the chairman believes we should be doing.

Let me make the following statement. I want to invite everyone to stay at the conclusion of the hearing to see the demonstrations from Apple Classroom of Tomorrow program. That means all of the visitors we have, reporters and correspondents that would want to participate. And we can, I guess, get right into that right away now.

We want to thank you very much for being with us. It's been very helpful, and we assure you that we'll continue to pursue this most important area. Thank you very much.

The committee stands adjourned.

[Whereupon, at 12:46 p.m., the committee was adjourned, to reconvene subject to the call of the chair.]

APPENDIX

NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS

Statement
on
The **MATHCOUNTS** Program
as it relates to
Science and Mathematics Education

Prepared By
The National Society of Professional Engineers

June, 1989

This statement describes the MATHCOUNTS program, a national math competition for seventh and eighth grade students designed to increase students' interest and ability in mathematics and to heighten public awareness of the importance of math. The National Society of Professional Engineers (NSPE) is pleased to submit this statement to the House Committee on Science, Space, and Technology, following hearings on U.S. science and mathematics education. NSPE is a membership organization of 75,000 engineers employed in all technical disciplines and all areas of practice, including education, industry, government, private practice and construction.

1420 KING STREET ■ ALEXANDRIA, VIRGINIA 22314-2715 ■ 703/684-2800 ■ FAX 703/836-4875

The need for improvements in U.S. math and science education has been well documented. In math skills, American students trail discouragingly behind their counterparts in other parts of the world. If the United States expects to be a strong leader in the global economy, it is critical that we start now to ensure a technically qualified work force. To do so, we must challenge all aspects of our educational system, from curricula to teacher training and compensation.

Similarly, we must find innovative approaches to promote math and science as exciting and challenging experiences that lead to rewarding career opportunities. MATHCOUNTS was created in 1983 in response to the declining level of math literacy in America. As noted in 1983 by Ronald Reagan, "We must create a new awareness in our young people to meet our country's technological needs of today and tomorrow. We need mathematicians, scientists and engineers. Programs such as MATHCOUNTS can help to encourage our young people to develop their math skills."

Analogous in concept to the national spelling bee, MATHCOUNTS is a national seventh and eighth grade coaching and competition program that fosters enthusiasm and prestige for math achievement. The program's success has been possible through the thousands of corporations, individuals and foundations that support the program at the local and state levels. MATHCOUNTS has received two presidential citations as an outstanding private sector initiative.

It is the first nationwide program of its kind, combining the efforts of education, business, government and the technological community to promote math excellence among junior high school students. MATHCOUNTS is a cooperative project of NSPE, the CNA Insurance Companies, the Cray Research Foundation, General Motors Foundation, the National Council of Teachers of Mathemathics and NASA.

The program has three primary objectives. 1) to improve the quality of math education and to broaden mathematics curricula in seventh and eighth grades throughout the United States; 2) to elevate the prestige associated with achievement in mathematics; and 3) to increase awareness among parents, educators and the general public of the importance of mathematics in our technological society.

The program builds skills, promotes strategic problem-solving and brings students together for a lively exchange of mathematical ideas through competition. MATHCOUNTS is directed at students at an age when they are formulating attitudes about math and technology--when they can still elect to take college math courses in high school to prepare them for future technical careers. Through MATHCOUNTS, parents, educators and the general public all are made aware of career opportunities in math.

Today, MATHCOUNTS programs exist in all 50 states, the District of Columbia, Guam, Puerto Rico, the Virgin Islands, the Department of Defense and the State Department school system. Each year, 7,500 schools nationwide--twice as many since 1983--register to participate in over 450 local and state competitions. Since the program began, over 3 million students have been involved in MATHCOUNTS. We owe this success to the commitment of MATHCOUNTS sponsors and the enthusiasm and hard work of more than 15,000 volunteers.

The competition phase of MATHCOUNTS begins in the schools in the form of a qualifying test. Students are coached in everything from basic arithmetic skills to math logic, probability and statistics, linear algebra and polynomials. Between September and the national competition in the spring, students and teachers work together in quizzes and drills to develop teamwork and skill. They are then ready to advance to regional and state competitions which could lead them to Washington, D.C., and the national math finals.

The MATHCOUNTS program is closely tied with the National Council of Teachers of Mathematics (NCTM) in development of program materials. Each September, teachers at thousands of participating schools receive a MATHCOUNTS handbook which contains study guides and practice drills. These materials include the most recent developments in math education. Question writers are experts in math and are chosen by the NCTM. Each year MATHCOUNTS selects a special topic that usually is not taught in junior high school, such as transformational geometry and probability, which gives students an opportunity to explore subjects to which they would not normally be exposed.

The MATHCOUNTS program allows students to be identified as "winners" in an academic event. Competitors are referred to as "mathletes," and, as in sports programs, individuals and teams receive trophies, plaques or certificates at all levels of competition. Winning students and coaches travel free to the national competition. An exciting part of winning at the national level is an expense-paid trip to view a space shuttle launch.

Through publicity, community involvement and a broad base of participation, MATHCOUNTS increases public awareness of the importance of math. Major sponsors and NSPE chapters cooperate to publicize MATHCOUNTS across the nation. As a result of these efforts, several governors have declared a "MATHCOUNTS Week" in their states. In order to reach the most students, MATHCOUNTS is available to all junior high schools, regardless of their size or financial status. There is no registration fee for schools or students, and coaching materials are provided at no charge.

Perhaps the best measure of MATHCOUNTS' success is to hear directly from those involved in the program. Teachers consistently report that confidence-building is one of the greatest benefits of

MATHCOUNTS. Students who normally might not receive attention for their math achievements are rewarded for success in math just as athletes are recognized for excellence in sports. An important aspect of the program is that all students benefit from the coaching sessions, not just those who are likely to compete.

Still a relatively young program, MATHCOUNTS is committed to helping reverse the declining level of math achievement in the nation's schools. The first mathletes of six years ago are now in college. We are beginning to track these students to determine their career paths and the impact MATHCOUNTS has had on their choices.

MATHCOUNTS will focus increasingly on the development of minority incentive programs, particularly in inner city school systems. Recognizing that the majority of students who enter math-oriented careers are male, MATHCOUNTS makes a special effort to involve more females in the program. In many states, members of the Society of Women Engineers conduct MATHCOUNTS coaching sessions. As role models, these women encourage girls to pursue math-related careers. MATHCOUNTS also will focus more on the development of coaching workshops to help teachers get the most out of MATHCOUNTS' programs and materials.

The United States must have a technically competent work force to succeed in today's international marketplace. As noted in Workforce 2000 by William B. Johnson and Arnold H. Packer, "Very few new jobs will be created for those who cannot read, follow directions, and use mathematics." To this end, we must make improvements now in math and science education. By focusing on the fun of learning math, MATHCOUNTS is striving to do its part.

CORPORATION FOR PUBLIC BROADCASTING

Donald E. Ledwig
President and
Chief Executive Officer

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Committee on Science, Space
and Technology

June 1, 1989

The Honorable Robert A. Roe
Chairman
Committee on Science, Space and Technology
U.S. House of Representatives
Washington, D.C. 20515

Dear Chairman Roe:

It has come to my attention that the Committee on Science, Space and Technology is conducting a series of hearings focusing on science and mathematics education. I would like to offer for inclusion in the record of your hearing an overview of the efforts by the Corporation for Public Broadcasting (CPB) to bolster primary through postsecondary education in America.

CPB is a private, nonprofit, nongovernmental corporation authorized by the Public Broadcasting Act of 1967 to facilitate the development and distribution of high-quality public service programs for all Americans. The Corporation has long recognized that it is in the public interest to direct sufficient resources toward the development of educational and instructional series and their ancillary materials for use in the home, the classroom, and in the library.

Recent studies indicate that as much as a quarter of the American labor force lacks the basic reading, writing, and math skills necessary to perform in today's increasingly complex job market. One out of every four teenagers drops out of high school and, of those who graduate, one of every four has the equivalent of an eighth-grade education. Employers are facing a proficiency gap in the workforce so great that it threatens the well-being of hundreds of U.S. companies which are now forced to pour millions into educational and training programs in order to meet basic levels of competency.

Public broadcasting in the United States is a multifaceted and diverse endeavor, consisting of many elements, including more than 600 independent local public radio and television stations. In this context, the principal task of the Corporation is to find, initiate,

1111 16th Street NW
Washington, DC 20036
(202) 955-5275

20 Years of Quality Programming

and finance the production of high-quality educational, informational, instructional and cultural programs of greater than local interest which are not available from other sources. The programs are produced by a variety of entities, including public broadcasting stations, minority-based production companies, independent producers and educational institutions. Through their educational content, innovative qualities and diversity, these programs are intended to enhance the knowledge and imagination of all Americans.

Since its inception, CPB has always strongly encouraged the use of public television as a supplement to textbook education. Currently, approximately 65 percent of the public broadcasting schedule is devoted to delivering educational programming during the school day. In conjunction with this, CPB-funded programming delivers a wide range of programming and services addressing educational problems both at home and in the classroom, including:

o 3-2-1 Contact, a science and technology series for eight- to 12-year-olds that encourages youngsters, particularly minorities and girls, to view science and technology as a vital part of everyday living;

o Square One TV, a series designed to encourage children's interest in, and enthusiasm for, math and is aimed at eight- to 12-year-olds;

o Reading Rainbow, a series designed to motivate young people, kindergarten through third grade, to read on their own; and

o Spacewatch, a new series on space science and exploration targeted to youngsters in grades 3 to 7, responding to the need to improve science instruction in the schools.

A major part of the Corporation's commitment to educational programming is instructional programming for use in and out of the classroom. One excellent example of the latter is the Annenberg/CPB Project. For the past eight years, CPB has helped fund the creation of video- and audio-based college courses and the demonstration of advanced technologies for use in higher education through this endeavor. These efforts have allowed students and faculty to collaborate at great distances and provided access to otherwise unavialable resources. Forty-four complete college courses are now either available or in production. Innovative applications of computers, laser discs, communication networks, and interactive video are now available to faculty and students.

Since 1980, the Annenberg/CPB Project courses, either in part or in whole, have been adopted by approximately 1,600 colleges and universities. Since 1984, the Project's efforts have garnered more than 100 awards and critical acclaim from broadcasters and educators for programs such as The Brain, The Constitution: That Delicate Balance, and Planet Earth.

Basic education skills are vital to the general well-being of our society, as well as to America's economic stability. As one response to the critical need for new and innovative methods of teaching tools, CPB in 1988 provided critical funding to the Satellite Education Resource Consortium (SERC). As part of the Star Schools program, CPB's funding allowed the planning and start-up semester of this project. SERC is an educational initiative designed to boost America's competitiveness in a global marketplace and is a partnership between CPB, state educational television networks or associations and state departments of education in eighteen states, serving 59 schools.

SERC currently offers courses such as Probability and Statistics, Introduction to Japanese, a teaching course for teachers in AP Calculus, a series of eight science seminars for students, and a series of eight forums and workshops for teachers. Next fall, SERC will offer five high school courses, two graduate courses, and an array of teacher in-service programs.

Not only has CPB funded programming as part of our commitment to education, but the Corporation has taken a leading role in developing other initiatives designed to strengthen the relationships between instructional programming, textbook materials, and other ancillary materials. As a cornerstone to these relationships, CPB has worked to strengthen the involvement of teachers, parents, and students in providing the best educational tools available.

To encourage teachers to make the most of available programming by linking material in textbooks to instructional programs that cover the same topics, CPB published textbook correlations for series such as Up Close and Natural or Community of Living Things to science textbooks. Other guides funded by CPB are a part of each major children's series. They help build lesson plans and provide follow-up activities for teachers to use in integrating Square One TV or 3-2-1 Contact into their classes. CPB also funded study guides for students to use with special series such as The American Experience and specials such as Pyramid.

Other educational initiatives funded by CPB include EDISON -- Educational Information Services Online -- an advanced nationwide computer network that connects teachers with a number of education information databases. This allows teachers to research educational materials, review new material, or see which of the hundreds of ITV series currently available can be incorporated into their lesson plans. Another project is Learning Link. Developed by WNET/New York, Learning Link provides public TV program descriptions, long-range schedules, and an avenue for exchanging teaching tips.

Finally, CPB is currently developing a brochure that is designed to promote partnerships in education. Included in this brochure will be information on classroom program production and distribution, print materials for classroom use of regular public television programming, SERC, electronic information services, pilot demonstration projects, community outreach activities and national awareness efforts. This brochure is being developed for school boards, superintendents, legislators, education advisors, foundations and national and local public television funders.

The brochure is intended to motivate potential partners between CPB, PBS and regional networks; with other broadcasters; with program producers and distributors; with textbook publishers; with state and regional departments of education; and with community groups, PTA's and teachers.

These and other programs and services offered by CPB and the public broadcasting community represent just a few of the valuable contributions public broadcasting has made, and can continue to make, to education. The job of educating our youth is too big for anyone to do alone. The commitment and vast pool of talent, imagination, and expertise of CPB and public broadcasting are limited only by the resources necessary to put them to work toward enhancing both conventional and innovative teaching methods. As always, CPB stands ready to provide whatever assistance it can to bring the best in educational programming and materials to all Americans.

CPB applauds the Subcommittee's attempt to focus greater attention on the importance of issues affecting education today. As always, we are pleased to offer our views and pledge the Corporation's commitment to assist in any way possible.

Sincerely,

Donald Ledwig

Donald E. Ledwig
President and
Chief Executive Officer